# Working Group for Agricultural Consumption Study

## Final Report

**Submitted to Maharashtra Electricity Regulatory Commission**

**Mumbai, Maharashtra, India**

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# Contents

## Acknowledgements

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The work presented in this report would not have been possible without the excellent support and full participation by MSEDCL. WG is thankful to all senior management of MSEDCL, it's IT department and field staff. WG wish to record that the methodology adopted in this report and analysis undertaken was possible primarily due to the efforts put in by MSEDCL in recent years for deploying AMR / MRI feeder metering infrastructure and more importantly, ensuring continuous maintenance and monitoring of these systems. This emphasis of MSEDCL management on building transparent and accountable metering infrastructure has enabled the WG to develop methodology for transparent estimation of AG consumption and to help address challenge of AG consumption estimation plaguing the sector for nearly a decade.

WG also records it's appreciation for work undertaken by ASCI and AFC, two survey agencies which covered more than a lac consumers within a short span of four months and provided important field based feedback. Advice and insights provided by Advisors Dr Shashank Bhide and Shri P.H. Bhagoorkar, Dept. of Economics and Statistics, GOM to the WG and special invitees has also helped immensely.

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# Abbreviations

| | |
|---|---|
| ABR | Average Billing Rate |
| ACoS | Average Cost of Supply |
| AG | Agriculture |
| AGWG | Agriculture Study Working Group |
| AMR | Automated Meter Reading |
| DISCOM | Distribution Company |
| MERC | Maharashtra Electricity Regulatory Commission |
| MRI | Meter Reading Instrument |
| MSEDCL | Maharashtra State Electricity Distribution Company Limited |
| MSEBHCL | Maharashtra State Electricity Board Holding Company Limited |
| MTR | Mid Term review |
| MYT | Multi Year Tariff |
| PAU | Punjab Agricultural University |
| SERC | State Electricity Regulatory Commission |
| T&D | Transmission and Distribution |

# Working Group for Agricultural Consumption Study – Final Report

## 1. Introduction and Context

Electricity consumption by agriculture consumers constitutes almost 1/5th of total electricity consumption in India. In most of the agriculture dominant states, the sale of electricity for agriculture is reported to be in the range upwards of 30%. Out of such reported sales, significant portion is 'Estimated Sales' owing to a large number of agriculture consumers being unmetered or with no energy meters installed. Based on review of statistics carried out, it is observed that more than 35% AG consumers in states like, Maharashtra, Gujarat, M.P are unmetered with exceptions of Punjab where 90% of AG consumers are unmetered and in Rajasthan only 10% of AG consumers are unmetered. Supply of electricity without meters remains a fact even after around 17 years of implementation of the Electricity Act, 2003 which has mandated supply of electricity only through meters, in pursuance of its Section 55.

While most State Electricity Regulatory Commissions have issued directive for 100% metering, it is being followed by utilities mostly in terms of releasing new connections. The conversion rate of unmetered consumers to metered has been very low owing to various practical difficulties and on field challenges. Thus, it is inevitable that unmetered consumption in the Agriculture category will have to be determined on estimation basis. States have been adopting various methodologies for 'estimating unmetered AG sales' which have evolved over time. Efforts have been put in by various states to improve upon the approaches adopted earlier. Restatement of AG sales based on improved methodology or availability of data has been a recurring phenomenon and many states have undertaken restatement periodically. Ascertaining the right quantum of sales to every consumer category including the AG category is important as the same would ensure proper accounting of energy, distribution loss accounting, consumer category-wise revenue and cross-subsidy/subsidy requirements. The per unit gap (ABR - ACoS) for AG consumer is in excess of ₹2 per unit in most of the states, thus appropriate accounting of energy catered to AG consumption has great influence on the financial health and on the cashflows of the distribution utility.

**The Maharashtra Case:** Maharashtra has about 40 lakh of AG consumers, almost all in MSEDCL area, out of which over 15 lakh AG consumers are unmetered. For the purpose of approving AG sales of unmetered consumers, Maharashtra Electricity Regulatory Commission (MERC), over time had adopted various methodologies since FY2000-01. These entailed arriving at AG consumption index based on sample meter readings, assessed hours of supply per Annum,

feeder input on AG feeders etc., and estimating unmetered AG sales based on the so determined index. While doing so, MERC had primarily relied upon data submitted by MSEDCL. MERC had also issued directives for 100% metering of AG consumption and in the interim directed to estimate unmetered AG sales based on reasoned methodology. MERC has been directing assessment of AG consumption through independent third-party agency from as far as 2011 but no such satisfactory study was carried out. (MERC order in case no 121 of 2014)

In 2014-15, MSEDCL reported significant increase in the AG sales without any corresponding increase in the number of consumers or Connected Load. (viz. **~23%** y-o-y increase of AG sales when Connected Load y-o-y increase was only **4%**, so increase in AG Index of **19%** needed further detailed scrutiny). During the proceedings of case no 48 of 2016 MSEDCL informed the commission that "As per the directions of the MSEB Holding Company Limited (MSEBHCL), a three-member Agricultural Consumption Committee has been constituted which will look into the actual as against the billed load and consumption". It further stated that "MSEDCL has appointed the Indian Institute of Technology (IIT), Mumbai to assist the Committee for carrying out this study of agricultural consumption in Maharashtra." MSEDCL stated that report of this committee will be available by March 2017. While welcoming formation of the committee, the commission noted that "acceding to MSEDCL‟s request to restate agriculture sales based on the Committee Report only at the time of MTR, would imply not recognizing the apparently higher level of Distribution Losses and postponing efforts to reduce thereby at least two more years." Hence, in the said order commission estimated AG sales based on circle-wise AG index and feeder energy-based accounting and stated that "The Commission would undertake a detailed review of the methodology of determination of AG Sales after the Report is finalised."

Accordingly, Commission expressed need to carry out a third-party independent assessment study for ascertaining the un-metered agriculture consumption Index. In the interim, MERC adopted the methodology of ascertaining Circle-wise AG Index using feeder level data (feeder input, reported consumption, billed units, connected load, etc.) of AG separated and AG SDT feeders with predominant agriculture consumption, for estimating unmetered AG sales. The relevant extract of the ruling of the Commission in the MYT Order (Case 48 of 2016) is reproduced as under:

> *"…While the Commission recognises that the AG Index based on the existing methodology followed by MSEDCL needs to be revisited, validation of the data and this methodology, and the anomalies and limitations of the existing processes for assessment of AG Index would emerge from the Committee's Report.*

*However, awaiting the findings of the Committee would lead to delay in the recognition of a more realistic present level of Distribution Loss and consequently defer the actions required to reduce it. Therefore, the Commission has decided to adopt this methodology based on Feeder-based Energy accounting of AG separated Feeders and AG separated Feeders with SDT to determine the Circle-wise AG Index, as explained in the preceding paragraphs."*

Pending such study, MSEDCL in subsequent tariff petition proposed different methodologies to estimate AG sales based on secondary data. For FY 2014-15 and FY 2015-16, MSEDCL estimated AG sales with steep increase in sales compared to previous years with the reason that, due to shortfall in rainfall, there was higher groundwater requirement resulting into higher electricity consumption in rural areas. It was submitted by MSEDCL that the methodology adopted to estimate AG sales was based on EHV input and data pertaining to this parameter is sourced directly from the incoming EHV feeder of MSETCL with least possibility of manual intervention. MSEDCL also submitted another statistical study carried out for AG consumption analysis based on various parameters such as rainfall, cropping pattern and agricultural production in support of the claim made for increase in AG sales.

Owing to no concrete methodology and in the absence of Committee Report, MERC continued to consider the Circle-wise AG consumption indices arrived at to approve AG sales. In view of above, MERC had approved lower AG sales in various years compared to that reported by MSEDCL. Besides, since MSEDCL has not yet submitted the Committee Report, the Commission in the latest MTR Order (Case No. 195 of 2017 dt. 12 Sept, 2018) decided to conduct an independent Study for assessment of AG sales. The relevant extract of the ruling of the Commission in the MYT Order is reproduced as follows:

*"In the previous MYT order, the Commission had disallowed 2,414 MUs of AG sales in FY 2014-15 and 3,400 MUs of AG sales in FY 2015-16. In the MTR Petition, MSEDCL has requested the Commission to approve the AG sales for FY 2014-15 and FY 2015-16 without any disallowances. In the review order Case No. 176 of 2016, the Commission had decided to revisit the disallowances in the MTR Petition on the basis of statement by MSEDCL that the Committee report is expected by March, 2017. However, the Commission notes that MSEDCL has not yet submitted the report as elaborated earlier in this section.* ***Hence, the Commission now shall conduct an independent study through an agency for assessment of Ag sales, which shall form the basis of establishment of Ag sales from FY 2014-15 and in subsequent years. The Commission shall appoint an independent 3rd party agency to undertake such study. Further the***

***Commission shall define a detail ToR in due course of time and would be published on website." … (Emphasis Added)"***

Thus, MERC concluded that various methods adopted by MSEDCL for estimating AG sales were inadequate and failed to realistically assess AG sales, and hence it is inevitable to undertake assessment of AG sales through independent agency. In this context, the MERC constituted a Working Group for Agricultural Consumption study (AGWG). Objectives of the WG, Members of the WG, and their respective Terms of Reference were published by MERC vide notification dated 2 November 2018 and was uploaded on the Commission's website. This is included as Annexure 1. Composition of the WG is as below.

i. Executive Director / Director, MERC – Convener
ii. Prayas (Energy Group) - Member
iii. Idam Infrastructure Advisory Private Limited – Member
iv. Dr. Shashank Bhide (Economist and Ex. Officio of NCAER) – Advisor
v. MSEDCL – Special Invitee

Subsequently, Mr. P.H. Bhagoorkar, Dept. of Economics and Statistics, GOM was also invited as Special Invitee to AGWG.

Upon its constitution AGWG has convened 11 meetings, carried out detail deliberations on the contours and approach for the study, conducted field surveys through appointed Survey Agencies and carried out extensive analysis of data obtained through field survey as well as from MSEDCL. In January 2020, WG submitted interim report of its findings to MERC. MERC then published the interim report and invited public comments on the same. This final report is prepared after considering comments received on the interim report. Survey of around 1.33 Lakh AG consumers across 502 feeders have been completed and considered in this report. Key findings and results based on this survey data and extensive analysis by the AGWG are presented in this report. As per Commission's order in case no. 195 of 2017, mentioned above, findings of the AGWG would form the basis for "*establishment of Ag sales from FY 2014-15 and in subsequent years"*. This report covers AGWG's findings on validating metered AG consumption, and validation of AG consumption[1] based on feeder meter input. The report also presents suggestions regarding methodology for ascertaining the AG Sales for FY 2014-15 and for 3rd Control Period (FY 2016-17 to FY 2019-20) and procedure for measurement and estimation of AG consumption for future period.

[1] In this reports AG consumption and sales are used interchangeably

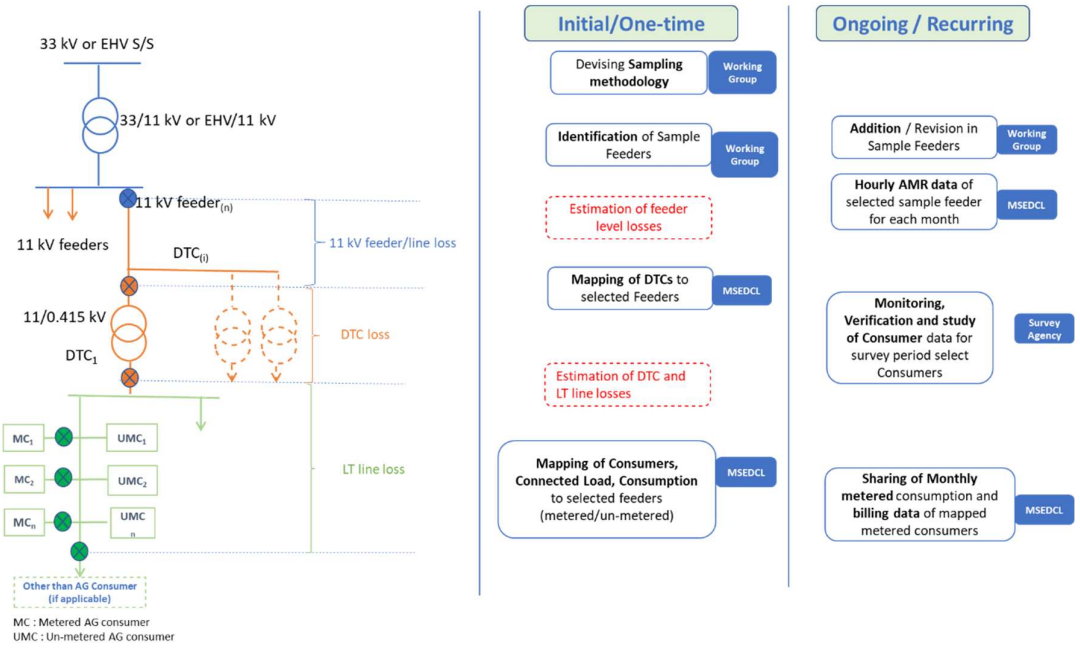
## 2. AG Working Group and Approach for AG study

This section of the report discusses briefly the overall approach for the study, key learnings from the pilot survey and key deliberations during the working group meetings. In view of the overall objectives and considering comprehensive nature of the AG Study, it was proposed to undertake the Study in stages to provide focused attention to each stage and to provide flexibility to undertake course correction, if necessary, as the study progresses. The entire scope of the study was divided into stages and actions to be undertaken in each stage were clearly outlined. These are listed below

1. **Formulation Stage:** Deciding Sampling philosophy, Devising sampling methodology, Selection of sample size of feeders to be surveyed, Identification, and collection of feeder and other relevant data from MSEDCL
2. **Data handling and management stage:** Establishing platform using IT tool for data capture, archive and reporting framework for further analysis
3. **Survey Stage:** Mapping of Consumers to the right feeders and DTC, DTC Survey, Consumer Survey, Monitoring of survey work by survey agencies
4. **Analysis and Reporting Stage** Detailed analysis of feeder data and survey data, Preparation of report on the overall study conducted

Based on deliberation in the initial working group meetings, an overall framework for undertaking the AG study was evolved. The same is represented in the form of a Schematic Diagram depicting the stage-wise activity, role of each entities viz. AGWG, MSEDCL and Survey Agencies.

*Figure 2-1 Schematic diagram of AG WG Approach*




**Above schematic diagram is only representative to outline the overall framework for undertaking the study.*

As shown, the activities involved were categorised into one-time activities such as devising sampling methodology, identification of sample feeders etc and recurring activities such as sharing of monthly AMR data, M&V of the AG Study etc. The single line diagram shows the elements in the distribution network such as voltage level, load, metering data etc. must be considered as part of the study. The single line diagram also provides an overview of the network elements starting from the HT feeder emanating from the substation, DTCs, LT network and consumers/load which are the basic blocks that need to be mapped for the survey and study thereof.

Based on the stages decided for conducting the study and approach adopted during each stage, study has been carried out. Detailed approach and methodology adopted is discussed in subsequent sections.

## 2.1.Key deliberations and important milestones

Working Group convened eleven meetings over the past one year since its constitution. The key activities carried out by the AGWG have been summarised below.

i. **Questionnaire finalization:** As part of this activity, a Questionnaire for field survey was prepared and shared with MSEDCL's IT team for development of mobile based survey app, tested during the pilot survey and made suitable modification for final incorporation in the survey mobile app.

ii. **Pilot Survey, entities appointed, feeders selected:** Before going into full-fledged state-wide field survey, AGWG decided to undertake pilot survey. This was useful in understanding some of the on-ground challenges and accordingly modify and finalize questionnaire, Mobile app and subsequently- tender documents for selection of survey agency for full-fledged survey. 9 feeders were selected for pilot study covering Pune, Aurangabad and Nagpur Zone, and the pilot survey was carried out through 4 survey agencies. Due to lack of water, rotational supply, taking actual load/ voltage details using tong tester was found to be not feasible. Also, this requires greater cooperation from consumer as well as support of MSEDCL linemen for measurement, which is not always possible. Hence, it was concluded that tong tester-based measurement would not be possible for such large-scale survey (as survey of around 1.5 lac consumers was planned)

iii. **Revision of Questionnaire & Modification of Mobile APP**: Based on feedback received from the survey agencies and the pilot survey, Questionnaire and mobile APP was modified to address the difficulties encountered during pilot stage and learnings from pilot stage helped in refining the approach for field survey and aligning preparatory activities prior to undertaking state-wide field survey.

iv. **Support from MSEDCL sought:** Based on deliberations in the working group, it was acknowledged that continuous support from MSEDCL was necessary on some of the key aspects for successful completion of the survey and AG Study.

   a. Development of Mobile APP (MSEDCL support): Considering expertise of the IT team of MSEDCL, support was availed by the AGWG for developing survey mobile APP.

   b. Providing AMR & other static data of the selected feeders: AMR data of feeder input of selected feeders was identified as a crucial parameter for analyzing the AG consumption. Such data was necessary to obtain feeder level energy consumption in the selected feeders across a period of 1 full year (FY 2018-19).

c. Continued support to Survey team during field survey: MSEDCL concerned staff and substation in-charge was well acquainted with the field survey support requirements and provided necessary support on field. Similarly, back-office IT support on Mobile App/queries were addressed on timely basis as survey team encountered the same.

v. **Devising Sampling methodology for full-fledged state-wide survey:** AGWG deliberated on the sampling philosophy to be adopted and in devising the sampling methodology for carrying out full-fledged state-wise survey. Accordingly, a draft sampling philosophy and sampling methodology was prepared.

**vi.** **Inviting Comments on sampling methodology:** The draft sampling philosophy and sampling methodology was published on MERC website soliciting comments from stakeholders. Comments were received and deliberated in the AGWG meetings. Gist of the comments and deliberations by AGWG is presented in the subsequent section.

vii. **Decision on survey & discussion of broad approach of analysis of survey data:** AGWG deliberated on the approach to be followed for analysis of AMR data and survey data for arriving at AG consumption norms viz. data which was made available by MSEDCL (AMR data) and that obtained through survey.

viii. **Tender Publication for selection of survey agency and appointment of Survey Agency by MERC:** AGWG provided input to MERC in preparation of tender document for publication and for selection of the survey agency. Two Survey Agencies were selected by MERC for undertaking detailed survey. Training of survey agency team members for use of mobile App and essentials of field survey was coordinated through workshop and one-to-one meeting with survey agencies.

ix. **Mechanism for Monitoring and Verification of survey**: Various mechanisms for monitoring and verification of survey were deliberated and steps like One-on-one meeting with survey agency, online tracking of survey results & progress through web console, approval process involving supervisor of the survey agency approving survey data uploaded by surveyor on ground, were deployed.

x. **Review of Quality of Survey:** Random quality checks of survey data uploaded &/approved by each survey agencies were carried out by the AGWG and feedback was provided to respective agencies regarding few discrepancies observed. This enabled survey agencies to undertake timely corrective steps.

**xi.** **Study of other State practices:** The AGWG also reviewed the practice followed by select AG dominated states to understand the methodology of AG sales estimation in respective states, methodologies adopted over the period, challenges of the methodology etc. Undertaking such study enabled the AGWG to have insights in to practices followed in other States. Detailed summary of methodology and comments on the same by AGWG is presented in the subsequent section of this report.

xii. **Survey & AMR data Analysis:** Based on survey data and feeder AMR data, extensive analysis has been carried out by the AGWG. Base year for the study was considered as FY 2018-19. Data of 502 - AG dominant feeders covering around 1.4 Lakh consumers were analyzed as part of the study.

xiii. **Presentation of draft findings, preparation of Interim report and public comments thereon:** The context, draft analysis and recommendations of the AGWG as part of the AG study were presented and discussed in the WG meeting, including MSEDCL. MSEDCL provided certain comments on this analysis and findings, and the same have been considered while preparation of this report. For example, MSEDCL again contended to use EHV Substation input based approach for estimation of AG sales. MSEDCL had made similar submission to MERC during case 195 of 2017, and MERC has already decided not to rely on this methodology. Hence, the working group also decided not to rely of EHV substation inputs based methodology and to develop methodology based on feeder AMR input / data. Interim report covering methodology, analysis and findings was published and public comments were sought. This final report has been prepared after this extensive process. AGWG took into consideration inputs and comments by advisors and also responded to their queries. Summary of comments received on interim report is presented in Annexure 5. Broadly, comments on interim report are on two aspects. One regarding data and assumptions, covering issues such as technical loss calculation, consideration of feeder input data with assessment, AG connected load and Non-AG sales as per 21 Nov. 2019 data submitted by MSEDCL, Using HT AG LIS hours of operation as benchmark / reference etc. Second set is regarding implications of AG sales re-statement and way forward including issues such as treatment of past losses, future estimation, AG metering and billing, etc. These are covered in subsequent sections of the report.

## 2.2.Review of AG consumption methodology/practices adopted in select states

Agriculture consumption estimation has been a major issue of regulatory concern for long in many states due to large share of un-metered consumption. In the absence of reliable metered data for large consumer base with wide variation in the cropping pattern, seasonal variation and regional/zone diversity factors, utilities have resorted to different approaches & sampling methodologies, energy accounting/audit practices for assessment of the consumption. In the past, questions have been raised around reported metered consumption data through regulatory process across various states. The element of uncertainty surrounding assessment of agriculture consumption has direct impact on estimation of distribution losses and affects the utility and consumer alike.

AGWG considered it appropriate to compile and study the AG consumption methodology and practices followed by SERCs in different states. Thus, AGWG has studied the AG consumption methodology /practices/studies undertaken by few SERCs over the past 10 years or earlier to understand how these methodologies have evolved and parameters considered therein. The states selected are Maharashtra, Gujarat, Punjab and Rajasthan, where the agricultural consumption forms predominant share of total consumption of the state, which varies from 25% to 35%. In these states, the degree of metered to un-metered consumer base has varied from Maharashtra (62:38), Gujarat (68:32), Punjab (9:91) and Rajasthan (94:6) providing opportunity to study approaches followed in different conditions.

It is evident from the scrutiny of the regulatory orders that SERCs have adopted varied approaches for assessment of AG consumption including independent field studies, sample energy audit, feeder-based energy accounting etc. The methodologies have also evolved as the availability, granularity (division/circle/zone) and frequency (seasonal/monthly/quarterly) of the data has enhanced. Limitations of the methodologies have also been highlighted in respective Orders. Feeder Input based division level assessment AG consumption has been followed in Punjab but it also entails estimation of loss at sub-transmission/distribution level. However, comprehensive Feeder input based assessment using AMR/MRI data has been possible in Maharashtra due to comprehensive feeder metering plan put in place for AG separated/AG-dominant feeders by MSEDCL.

As per approved AG sales and connected load figures available under most recent ARR/Tariff Orders, composite AG Consumption Index (kWh/HP/annum) derived for the select states varies from Maharashtra (1354 – FY19), Gujarat (1043 – FY18), Punjab (904 – FY17) and Rajasthan

(1270-FY19). More detailed analysis and compilation of regulatory methodologies/practices followed in select states is presented in the Annexure 2.

This review of AG consumption estimation practices in multiple states is undertaken primarily to understand methodologies adopted by different states and issues encountered in the same. It would not be appropriate to directly compare consumption norm adopted in one state with other state as there is significant variation in agro-climatic zones as well as cropping pattern and irrigation / farming practices in different states. Also as the review indicates, depending of quality of data available, AG sales estimation methodology and hence, quality of AG sales estimation would also improve.

[Refer Annexure 2 for state specific case notes covering compilation of AG Consumption assessment methodology followed by SERCs over the period for select states viz. Maharashtra, Gujarat, Punjab and Rajasthan.]

# 3. Feeder Sampling, Survey Approach and Consumption Estimation Methodology

In the initial meetings, working group deliberated on various aspects of the study to be undertaken. To carry out study it was essential to undertake field survey for assessing on-field status of AG consumer metering. For adopting feeder input based AG sales estimation also it is essential to validate consumer mapping and carry out detail analysis of feeder meter based input. Both these aspects require selection of sub-set (sample) of feeders for detail study as this field validation and input meter analysis cannot be undertaken for entire population of AG feeders (around 10,000) within given time and financial resources. For the purpose of development of sampling methodology, AGWG has considered MSEDCL submission that, there are around 41.54 Lakh AG consumer connections (comprising metered - 26.50 Lakh and un-metered-15.04 lakh) with connected load of 210.84 Lakh HP (metered – 133.44 Lakh HP and un-metered-75.40lakh HP) as on March 2018. Sampling methodology and selected sample size should be representative enough to represent such vast/diverse universe of data and an appropriate sampling method need to be arrived at for conducting the survey. Accordingly, in WG meetings various factors for evolving appropriate sampling methodology were deliberated at length. Besides, a survey approach was also prepared and discussed during AGWG meetings with inputs of Advisor and with participation from Special invitees.

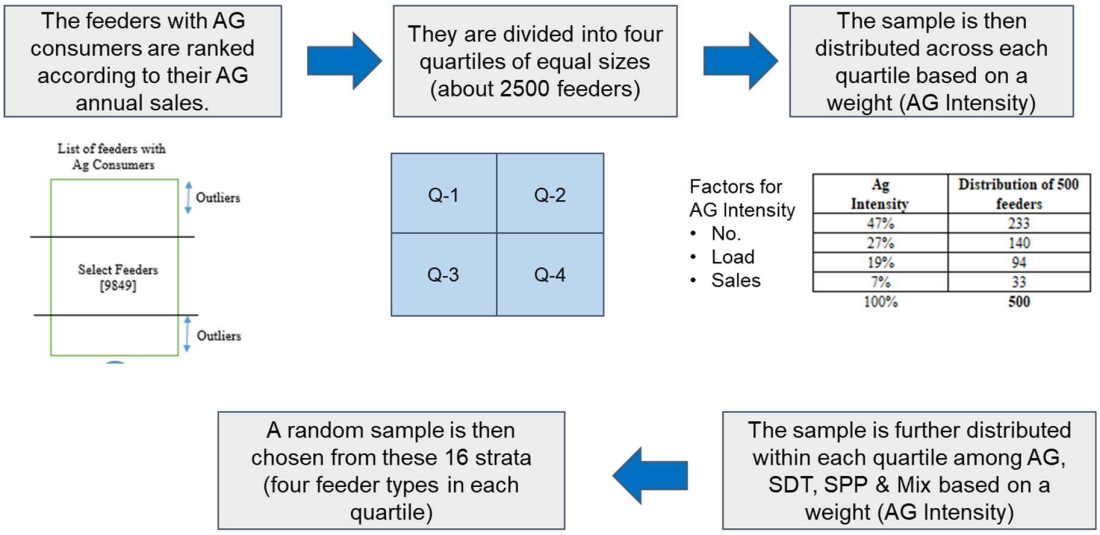
This section of the report discusses various aspects of the AG survey including the methodology for sample feeder selection, overall approach for the survey, Survey Questionnaire Design, pre-publication of the same, major Comments received on the above as part of the pre-publication, selection of survey agencies, monitoring and review framework adopted and the latest status of the survey. This session also presents feeder input based methodology considered by the AGWG for estimation of AG sales.

## 3.1.Feeder sampling approach

Agricultural consumption varies greatly based on season, rainfall, crop, irrigation practices etc. Based on notification for formation of AGWG and considering that in recent months, MSEDCL has made significant progress in AMR / MRI based feeder metering, it was decided to use a sample of AG feeders for detail analysis. **Though data for large number of AG dominant feeders is available, reliability and accuracy of these data for entire population of AG feeders still needs to be improved substantially. For example, a summary analysis of FY 17 – 18 and 18-19 data indicated negative AG sales for 100s of feeders, for FY 18-19, MSEDCL itself indicated one or**

**the other problem (wrong mapping / metering problem / load diversion) for over 1/3rd AG feeders. Further, as described in this report later, availability of consistent AMR / MRI meter data for full year is also an issue for large number of feeders.** For all these reasons it is essential to adopt a feeder sampling based approach and not just depend on entire feeder population data as submitted by MSEDCL. AG consumption is dependent on cropping pattern, area irrigated, source of water, irrigation practices, energy efficiency, rainfall etc. Implications of all these parameters ultimately reflect in AG consumption at feeder level. The sampling methodology adopted for the purpose of AG sales estimation and field survey had to ensure that selected sample size should be representative enough of the diversity of agriculture usage, varying cropping pattern, seasonal variation throughout the state. The sample should also have regional/ geographical diversity**,** covering different regions and circles, metered and unmetered connections, different types of feeders such a pure AG feeders, single phasing feeders and Special transformer feeders. As reasonably reliable feeder input data (based on AMR / MRI) was expected to be available, it was decided to use feeder as a basic unit of analysis. Considering availability and capability of survey agencies, time required for survey, costs and other such practical, on field considerations, and need to select representative sample, AGWG decided to undertake field survey of around 500 AG feeders (around 5% out of total AG dominated feeders of around 10,00 feeders) spread across the state. **A stratified random sampling approach** was proposed for selecting the representative sample of feeders. The sampling frame consisted of about 10,000 agricultural dominant feeders in Maharashtra, which cover about 95 % agricultural consumers. Details on number of agricultural consumers, connected load, and annual sales (electricity consumption) and other required parameters for all these feeders were provided by MSEDCL. Feeder wise claimed annual AG sales have been considered as the primary criterion for stratification. Outlier feeders with obvious faulty data such as negative AG sales were excluded. The feeders are ranked according to their total AG annual sales and then divided into four groups/quartiles of equal sizes. Each quartile has about 2500 feeders. It is observed that each quartile exhibits a fairly wide geographical distribution. The sample is then distributed across each quartile based on a weight which was estimated considering the total number of consumers, connected agricultural load, and total agricultural sales in each quartile. Within each quartile, the sample is further distributed across four different feeder types (LT Mix, LT AGD, LT SPP, and LT SDT) based on a weight calculated in a similar fashion as above. A random sample is then chosen from these 16 strata (four feeder types in each quartile). Figure 3.1 shows pictorial illustration of feeder sampling methodology adopted. Total 502 feeders were selected in this manner for survey and detail analysis. Based on this approach out of sample 502 feeders, 48% feeders belong to quartile 1, 28% belong to quartile 2, 18 % belong to quartile 3 and 6 % belong to quartile 4.

*Figure 3-1 Pictorial illustration of step-wise sampling*




This sampling methodology would result in agricultural electricity consumption estimated on these feeders being representative of the Maharashtra state as a whole. As such, this method enabled state-wide estimation of AG sales. Data collected through survey and feeder meter data along with other parameters as may be required were analysed to arrive at feeder level Agricultural consumption index. The results are then extrapolated to estimate the total annual agricultural electricity consumption in Maharashtra. This is detailed in later sections.

## 3.2.Survey approach

Along with analysis of feeder meter data and billing data, it was also necessary to assess field conditions on these feeders, especially regarding consumer metering and pump usage practices. Hence, survey and on field collection of data was carried out through independent survey agencies appointed by MERC. AGWG periodically reviewed work of survey agencies and data collection. Data collection was undertaken through a Mobile App (mobile based application) installed on a mobile device. Based on actual survey experience, sampling methodology, questionnaire, and necessary modification was undertaken during the course of survey. Considering practical aspects, it was decided to survey around 1.5 lac AG consumers on selected 502 feeders. For this purpose, one third of 502 feeders (spread across all quartiles) were selected for 100% consumer survey, one third feeders were selected for survey of all consumers on 50% DTCs and one third feeders were selected for survey of all consumers on 25% DTCs. **To ensure proper sales estimation, MSEDCL was repeatedly asked to validate / correct consumer mapping on these feeders. MSEDCL provided feeder wise consumer and DT data and confirmed that it has corrected consumer mapping for identified feeders for survey.**

To enable a structured survey and data collection, a detailed questionnaire was prepared. The survey questionnaire covered questions relating to meter status, pump status and pump operating days and hours, indicative cropping pattern and irrigation methods, distance from DTC etc. The zone-wise, circle-wise spread of the selected sample is shown in the table below.

*Table 3.1 Zone-wise sample of feeders and consumers selected for survey*

| Sr. No. | Zone | Circle | No of AG Feeders | No. of AG Consumers (universe) | Consumers to be surveyed |
|---|---|---|---|---|---|
| 1 | Akola Zone | Akola Circle | 2 | 951 | 322 |
| 2 | | Buldhana Circle | 21 | 15435 | 9398 |
| 3 | | Washim Circle | 11 | 6772 | 4102 |
| 4 | Amaravati Zone | Amaravati Circle | 9 | 5461 | 2973 |
| 5 | | Yavatmal Circle | 13 | 9801 | 5604 |
| 6 | Aurangabad Zone | Aurangabad Circle | 20 | 11022 | 6476 |
| 7 | | Jalna Circle | 14 | 8270 | 5265 |
| 8 | Baramati Zone | Baramati Circle | 19 | 11588 | 7148 |
| 9 | | Satara Circle | 21 | 18829 | 9797 |
| 10 | | Solapur Circle | 54 | 22488 | 13408 |
| 11 | Gondia Zone | Bhandara Circle | 3 | 1514 | 648 |
| 12 | Jalgaon Zone | Dhule Circle | 11 | 4941 | 2869 |
| 13 | | Jalgaon Circle | 36 | 15048 | 9104 |
| 14 | | Nandurbar Circle | 13 | 5607 | 3699 |
| 15 | Kolhapur Zone | Kolhapur Circle | 15 | 8897 | 4679 |
| 16 | | Sangli Circle | 23 | 15262 | 9541 |
| 17 | Latur Zone, Latur | Beed Circle | 15 | 6332 | 3855 |
| 18 | | Latur Circle | 26 | 10315 | 6333 |
| 19 | | Osmanbad Circle | 22 | 13770 | 8505 |
| 20 | Nagpur Zone | Nagpur (R) Circle | 8 | 3288 | 1836 |
| 21 | | Wardha Circle | 4 | 2362 | 1154 |
| 22 | Nanded Zone | Hingoli Circle | 9 | 4187 | 2126 |
| 23 | | Nanded Circle | 19 | 8838 | 4895 |
| 24 | | Parbhani Circle | 2 | 303 | 249 |
| 25 | Nasik Zone | A' Nagar Circle | 51 | 24364 | 14803 |
| 26 | | Malegaon Circle | 29 | 14075 | 8088 |
| 27 | | Nasik (U) Circle | 27 | 13710 | 7845 |
| 28 | Pune Zone | Pune (R) Circle | 5 | 2596 | 1436 |
| | | **Grand Total** | **502** | **266026** | **156158** |

## 3.3.Public comments on sampling methodology and survey approach

Above sampling methodology and survey details were finalised after seeking stakeholder comments. Proposed / draft sampling methodology and the proposed / draft survey approach along with the Questionnaire was published on the website of MERC vide notice dated 6 May, 2019, and stakeholder's suggestions were solicited through newspaper advertisement and website notice. Comments were received on the proposed methodology from, Prof. Priya Jadhav, IIT Bombay, Maharashtra State Electricity Distribution Company Limited, Dr. Ajay Chandak, Maharashtra Veej Grahak Sanghatana, and Mr. Ramesh Sundaresan. Summary of these comments is included as Annexure 3.

AGWG observed that the stakeholders have supported the overall approach and the sampling methodology proposed by AGWG and few suggestions for improvement of the questionnaire and other suggestions for ensuring transparency in the process were made. AGWG further deliberated the comments/suggestions received and have accordingly incorporated suitable modification in the questionnaire, given due consideration to the factors during sample selection and prepared checklist for survey agencies and noted the support requirements/monitoring & verification requirements during field survey. All stakeholders supported the approach of using AMR based feeder input data for the study, analysis and accordingly study undertaken by WG is based on the feeder level AMR data. **AMR feeder meter-based approach also ensures that any variation in AG consumption due to factors such as rainfall, cropping pattern and irrigation practices would be captured in AG index. This also addresses MSEDCL concern that AG consumption index / methodology should be dynamic and enable year on year computation of AG consumption index to take into account annual variation of rainfall etc.**

As regards suggestion of sample size, the AGWG considered selection of 502 feeders which amounts to 5% of universe of AG dominated feeders is representative enough as per statistical standards for sampling considering stratified random sampling approach. As regards undertaking 100% consumer survey of all the selected feeder, the AGWG opined that while selecting feeders for consumer survey for 100%, 50%, 25% randomness and statistical consistency across quartiles and geographical spread has been ensured so that there is no bias in selection of consumers for field survey, however, this would help in optimising the cost and time, considering the overall timeline, efforts and budget involved for field survey. As regards suggestion for field measurement of HP of the pump, the AGWG, based on learnings from pilot

field survey, opined that field measurement has several challenges and prone to errors/capability of field surveyor and other factors such as water availability and availability of power supply during field survey etc. Besides primary parameters that need to be assessed as part of the survey are metering status of the AG consumers and validating consumer mapping, measuring HP load may not be necessary, for which there is already data available with MSEDCL.

Considering the above, the sampling methodology, survey approach and questionnaire was finalised, and MERC appointed two agencies for undertaking field survey. This survey commenced from 20 September, 2019 by both the agencies in the allotted zones to the agencies. During the survey, WG analysed the quality of survey and accordingly, survey agencies improved the performance. Survey agencies also discussed the issues faced by the teams in different zones of the State during the survey period. WG provided necessary training and support to survey agencies for undertaking field survey.

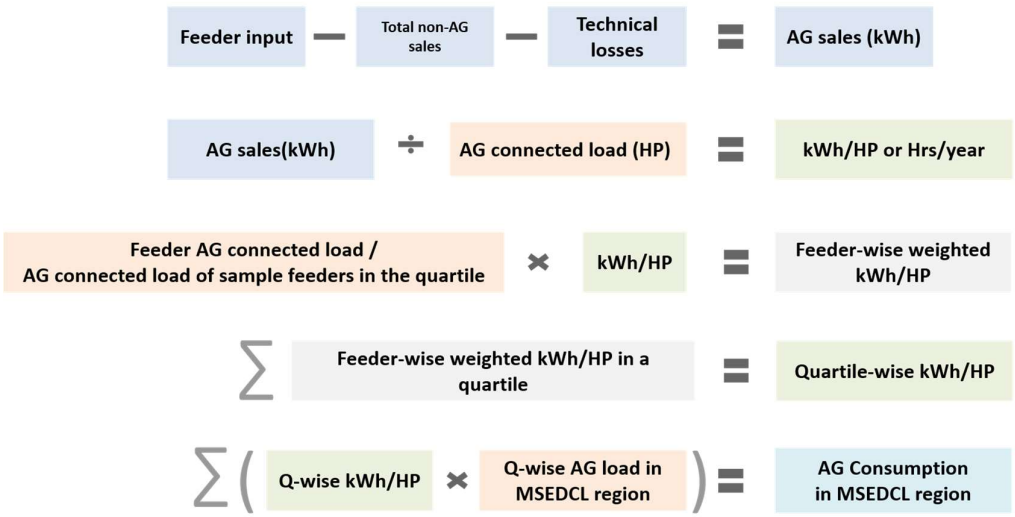
Survey Agencies have finally completed survey of about 1.33 lakh[2] consumers spread across the state. This report presents analysis of this data.

## 3.4. Methodology for estimation of AG sales based on quartile-wise AG consumption norm

Sampling of AG feeders for detail analysis is required as it is essential to ensure proper consumer mapping and availability of feeder meter data for full year, which may not be available for all AG feeders. After selecting feeders as mentioned above, MSEDCL was asked to provide complete feeder meter data and also to undertake validation of consumer mapping for selected 502 feeders and a field survey was undertaken to ascertain certain field conditions. Figure 3.2 provides schematic overview of methodology for AG sales estimation based on quartile-wise AG consumption norm.

[2] Initially survey of about 1.56 lakh consumers was planned as show in table 3.1. Upon revalidating consumer mapping, this number was reduced to 1.46 lakh. Out of this survey agencies competed and approved survey of about 1.33 lakh consumers.

*Figure 3-2 Overview of AG consumption estimation methodology*




As depicted in the figure 3.2, in this methodology, as a first step, feeder wise AG consumption norm / index is derived. This requires estimation of technical loss on the feeder and non-ag sales. For calculating feeder index, connected AG load on the feeder is taken as per MSEDCL database. **This implies that all pumps as per MSEDCL database are considered operational. Since meter-based feeder input is considered for computation of index, it also implies that no un-authorised load or consumption is assumed / considered on that feeder and entire consumption (i.e. feeder input less technical loss less non-AG metered sales) is considered to be from authorised AG consumers. In other words, considering connected load as per MSEDCL records for calculating feeder index, would also lead to consumption of any un-authorised load / excess load either from AG or non-AG consumers / theft being included in feeder index and hence in state-wide AG sales estimation. This would also imply that consumption of larger pump size than authorised is also covered in the index.** After deriving feeder wise index, weighted average index for each quartile is derived by assigning weight to each feeder in proportion of AG load on that feeder to total AG load of all sample feeders in that quartile. While deriving quartile-wise AG index, care needs to be taken that feeders with any irrational feeder consumption norm, should be excluded. This is explained further in chapter on estimation of AG sales for FY 18-19. Quartile wise AG consumption index such derived is then multiplied by total AG load for that quartile (considering total MSEDCL AG load on AG as well as non-AG feeders), and summation of such quartile-wise AG consumption gives total AG consumption for the given year. Application of this method for FY 18-19 and results of the same are described in chapter 6.

# 4. Survey Data Analysis and Findings

As discussed in chapter 3, the field survey covers around 1.33 lakh consumers, representing around 3.2% of total AG consumers in the MSEDCL area, spread across sample of 502 feeders. These feeders have a representation of all 4 types of feeders including mix and AG dominated. Further, these feeders have been grouped as 100%, 50%, 25%, on the basis of % of total AG consumers on the feeder to be considered for the consumer survey. A survey questionnaire was designed to seek key information from the consumers including, number of pumps, with their size, and operational status, rewinding history, metering status, season-wise pump usage, cropping pattern, and irrigation methods, etc. The data helps in ascertaining norms for consumption. This chapter presents analysis of this consumer survey data.

## 4.1.Status and coverage of agriculture consumer survey

Through specialised survey agencies survey of about 1.33 lakh consumers was undertaken. As can be seen both in the map and the pie-chart, (figure 4.1 and figure 4.2) the survey is geographically well-spread covering nearly all divisions and zones, which comprise of diverse cropping patterns, sources of water, irrigation methods, and different agro-climatic conditions. Survey is conducted over period from Sep-2019 to Feb 2020 which covered the peak rabi season during field visit by surveyors.

*Figure 4-1 Geographical coverage of AG consumer survey*

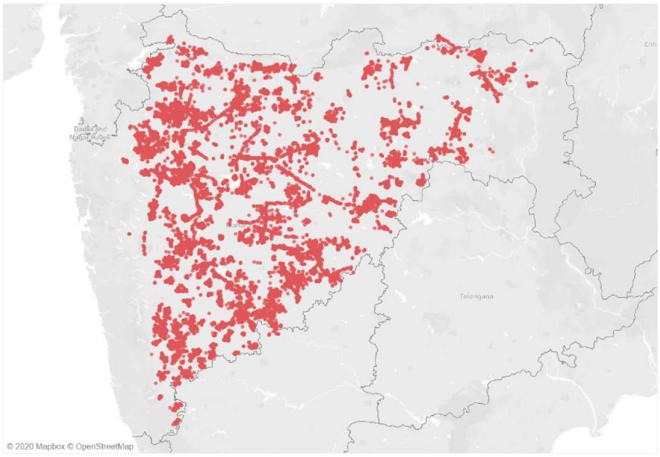
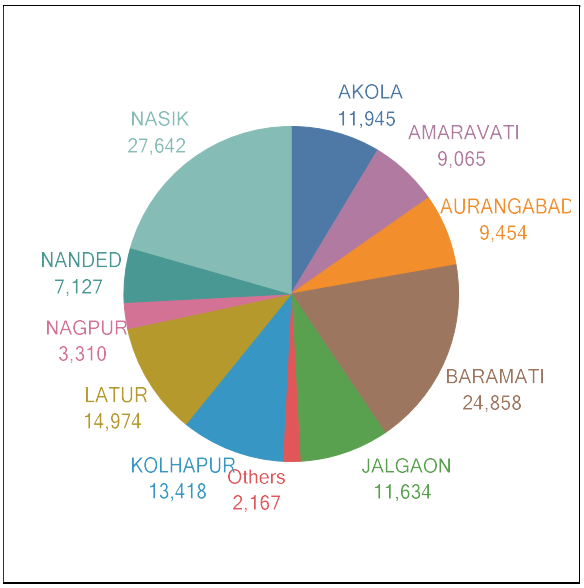


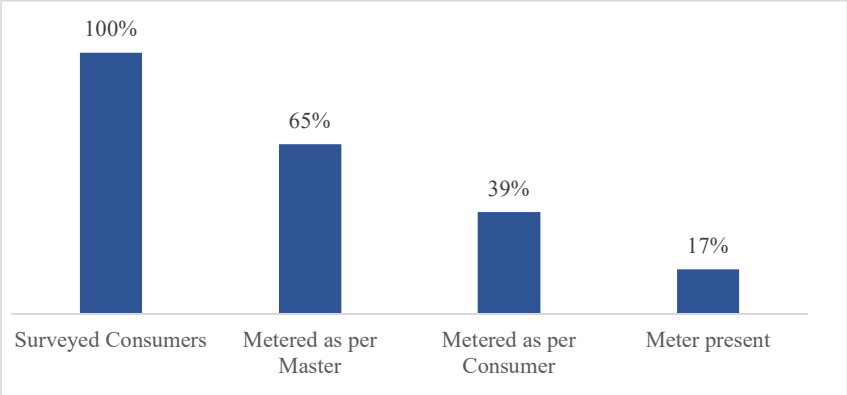
*Figure 4-2 Zone-wise break-up of AG consumer survey*




## 4.2.Metering status

For 1.33 lakh consumers surveyed, even though MSEDCL records indicated 65% metered connections, only 39% consumers reported a metered connection. Further surveyors could trace only 17% of consumers with meters actually present on field (Figure 4.3). This implies that compared to metered consumers as per MSEDCL records, meters are present only for 27% of metered AG consumers as per master record. There is considerable variation in metering status across zones. In some zones as compared to MSEDCL records, meters are present in less than 5% cases, while in most zones this % is between 20% and 35%. Only in one zone meters are present for more than 50% of consumers as compared to MSEDCL records.

*Figure 4-3 Status of agricultural consumer metering according to survey*



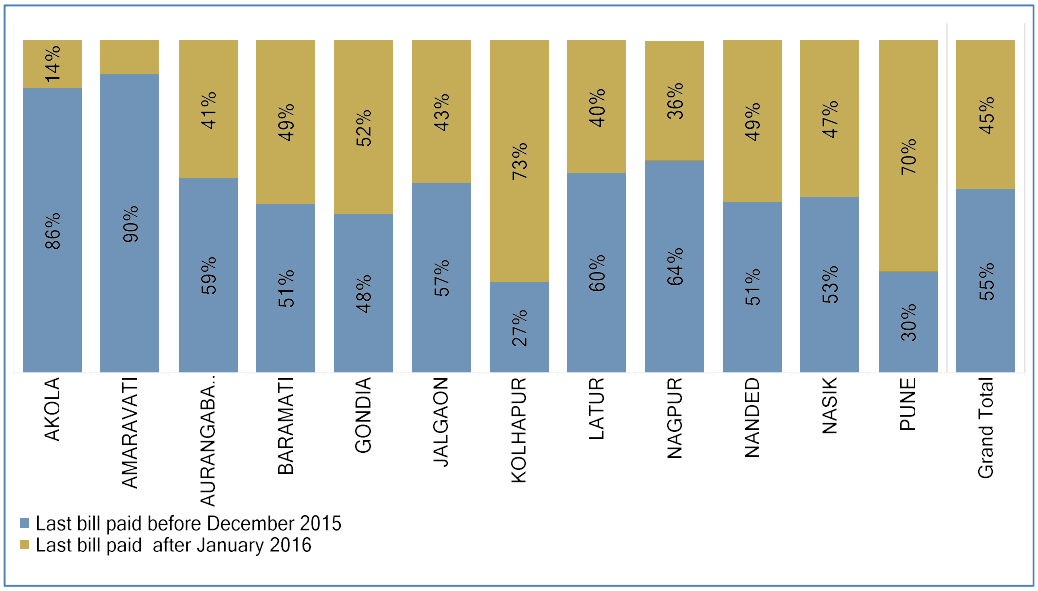
Moreover, out of around 23,400 cases in which meters were present on field, surveyors could capture meter readings of only 1,947 meters. This could be due to meters being locked in pump room, damaged meters, un-readable meters etc. On further scrutiny, it was observed that only 44 % i.e. 861 (out of 1,947) meters displayed progressive readings. To make matters worse, some of these meter readings were unreasonably high, flashing ~10,000 kWh of consumption for 5 HP load in a span of just two months.

The analysis of AG metering status based on field survey of nearly 1.33 lakh consumers spread across the state shows that compared to utility records, meters are present for only 27% metered AG consumers. Further in cases where meter readings could be validated, more than 50% readings were found to be incorrect. This highlights significant challenges in metering agricultural consumers.

## 4.3.Analysis of bill payment history

A zone-wise analysis of records of billing payment history also reveal an important point, which affects MSEDCL cash-flow significantly. It was observed that except in couple of zones, more than half of AG consumers have not paid any bill in last 4 years. Zone-wise summary of last bill payment is presented below:

*Figure 4-4 Bill payment history*



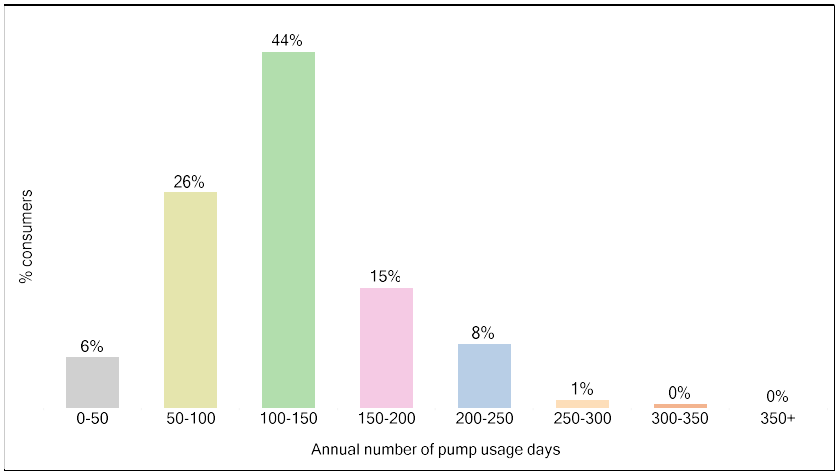

Note: This analysis is based on data of 1.1 lakh consumers, for which last bill paid data was available.

## 4.4.Pump usage analysis

### Annual days of pump usage

One of the prime objectives of the survey was to capture season-wise trends in pump usage by consumers (both in terms of the number of days per season and number of hours per day per season). The analysis of pump usage helps understand seasonal variations in the pump (and water usage). For this, the questionnaire provided different ranges such as 1-20 days, 21-40 days, and so on for the number of days of pump usage per season. In the analysis, AGWG has considered the higher end of the range. This means that, if a consumer reports 21-40 days of pump usage in Rabi, it is assumed that he uses a pump for 40 days in Rabi. Similarly, the number of days of pump used for the other two seasons is worked out to get the annual days of pump usage as per consumer. Frequency distribution plot, figure 4.5, for days of pump usage reveals that **nearly 70% of surveyed consumers use pumps between 50 and 150 days a year. 90 % consumers use pumps for less than 200 days a year, and just about 1.5 % consumers use pumps for more than 250 days a year. This indicates that average days of pump usage is unlikely to exceed 250 days / yr. for any AG feeder.**

*Figure 4-5 Annual days of pump usage as per consumer survey*

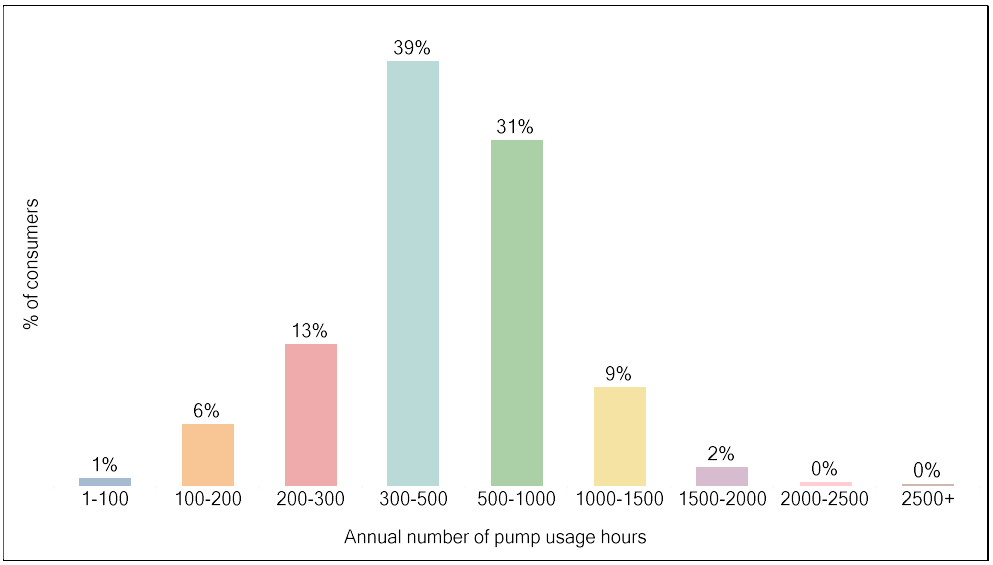



### Annual hours of pump usage

Another frequency distribution plot depicts annual hours of pump usage by consumers. Annual hours of pump usage for each surveyed consumer is computed by multiplying the high-end value of days of pump usage for all seasons with hours of pump usage per day reported by consumer

for the respective season. It is observed that 98% of consumers, use pumps for less than 1500 hrs. a year.

*Figure 4-6 Annual hours of pump usage as per consumer survey*




## Pump operational status

The next part of the survey was to get some sense about the operational status of pumps and have preliminary estimates of non-existent or defunct pump connections. For this, surveyors were asked to record whether the pump and/or panel exists on-site and whether the existing pump is in use (and if not, since when, etc.). About 3 % of surveyed consumers responded that their pumps were non-operational, while another 2.7% consumers responded that their pumps were operational, but neither pump nor control panel was present on site. Another 9.5% of surveyed consumers responded that their pump is operational but even control panel was not present on site of these consumers.

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# 5. Feeder Load Profile and Meter Data Analysis

In a very welcome development, MSEDCL has substantially improved feeder metering in the last few years with most urban and rural feeders covered with AMR / MRI feeder metering. This reduces any manual intervention in feeder meter reading and also enables collection of more granular, sub-hourly, data. AMR / MRI data from feeder meters is one of the most crucial inputs for the estimation of AG consumption. This section presents insights from the analysis of these feeder data.

## 5.1.Analysis of feeder meter data

A sample of 502 feeders was also selected considering the availability of feeder meter data. Slot wise AMR / MRI data for FY 18-19 was obtained from MSEDCL. This data consists of slot wise readings of parameters like line current, voltage, multiplying factor, active energy, and reactive energy. For most of the feeders, the duration of slots was 30 min (i.e. 2X24=48 slots per day), while for a small number of feeders, it was 15 minutes (i.e. 4X24=96 slots per day). For 216 feeders data for more than 75% slots was available, for 58 feeders data availability was 51% to 75% while for 211 feeders data was available for less than 50% slots. For 17 feeders data was not available or was found to be grossly erroneous. As discussed later, data for 70 feeders was found useful for full-year load profile analysis, as it was available for at least 90% slots for all 12 months of FY 18-19.

WG analysed these data for assessing load profile and current profile of sample AG feeders. This is presented in the next sub-sections.

## 5.2. Load profile of AG feeders

Based on slot wise data, different load conditions and duration of the same were analysed. The results of these analyses are summarised in table 5.1. MSEDCL has provided total AG and non-AG connected load of each sample feeder. As sample feeders are predominantly AG load feeders, AG load is more than 90% of the total load for nearly all sample feeders. The actual load registered on each feeder is compared with the total connected load of that feeder. It is found that out of 502 feeders, 307 feeders have registered actual load more than 100% of the total connected load, and 28 feeders recorded load more than 300% of the total connected load on the feeder. It needs to be noted that as mentioned above, for several feeders load profile data was available for less than 50% duration, and hence it is likely that on a full-year basis, the extent of excess loading would be much higher than shown in the table 5.1.

*Table 5.1 Excess loading of AG feeders*

| Hours of Excess Load | > 100% Load | > 200% load | > 300% load |
|---|---|---|---|
| 5 to 50 hours | 48 | 18 | 6 |
| 50 to 100 hours | 30 | 4 | 2 |
| 100+ hours | 229 | 41 | 20 |
| Total | 307 | 63 | 28 |

Out of 502 feeders more than 75% of data is available for only 216 feeders. AG load is highly seasonal and hence it is important to consider full-year data for analysis. It was found that 70 feeders had more than 90% data available for all 12 months of FY 18-19 and had the same meter number and multiplying factor throughout the year. Hence these 70 feeders were selected for further analysis. As shown in Table 5.3, these **70** feeders are well spread across different quartiles. All these are 11 kV feeders.

*Table 5.2 Quartile-wise break-up of feeders selected for detail load profile analysis*

| Quartile | Subset of 70 feeders | Sample 502 feeders |
|---|---|---|
| 1st | 47% | 48% |
| 2nd | 27% | 28% |
| 3rd | 20% | 18% |
| 4th | 6% | 6% |
| **Total** | **100%** | **100%** |

Out of these 70 feeders, 42 feeders (60%) have registered excess load (more than the total connected load on the feeder) for at least 10 hours, while 31 feeders (44%) have registered more than 125% of the connected load for at least 10 hrs. A review of the annual load duration curves of these feeders also shows the significant duration of excess load. The sample load duration curves of four feeders representing different levels of excess load are presented in figure 5.1. To further assess the extent of excess load, the share of total feeder input when the feeder load is more than the total connected load was calculated. **It was found that for 24 out of 70 feeders (34% feeders) more than 25% of annual feeder input was during 'excess loading' (load more than the total connected load of the feeder) condition.** In case of 4 feeders more than 50% of feeder input was during 'excess load' situation. Such extent of excess loading on sample AG feeders, even after validation of consumer mapping by MSEDCL is a serious issue. Such excess loading indicates presence of either significant excess load by registered AG consumers or huge unregistered load/ theft or major lacunae in consumer mapping. This needs to be considered while deriving feeder consumption norm based on feeder input.

Detail analysis of AMR / MRI feeder meter data reveals that nearly 35% to 45% of analysed AG feeders have recorded load much more than the total connected load on the feeder. Such excess loading indicates the presence of either significant excess load by registered AG consumers or huge unregistered load or major lacunae in consumer mapping. This needs to be considered while deriving the feeder consumption norm based on feeder input.

## 5.3.Analysis of current loading profile of AG feeders

In the feeder input based AG consumption estimation methodology adopted by the WG, feeder input is subtracted by feeder technical loss and Non-AG sales on the feeder to arrive at AG consumption on each feeder. Feeder technical loss estimation requires an analysis of the current loading of the feeder. Hence, similar to the load profile analysis described in the previous section, analysis of the current profile of shortlisted 70 feeders was also undertaken. Current duration curves of four representative feeders indicating different current loading profiles are depicted in figure 5.2. Statistical analysis of the current loading profile was also undertaken. This is shown

in table 5.3. This table shows the number and % of feeders (out of 70 feeders) for which current was above a particular value **for at least 25 % of average pump usage hours of that feeder.**

*Table 5.3 Current loading pattern of AG feeders*

| **Current threshold value**<br><br>**(for 25% or more of average pump usage hours for that feeder)** | **Number of feeders** | **% of feeders analysed** |
|---|---|---|
| > 100 A | 36 | 51% |
| > 150 A | 10 | 14% |
| > 200 A | 2 | 3% |

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*Figure 5-1 Feeder loading profiles- Feeder load duration curves*

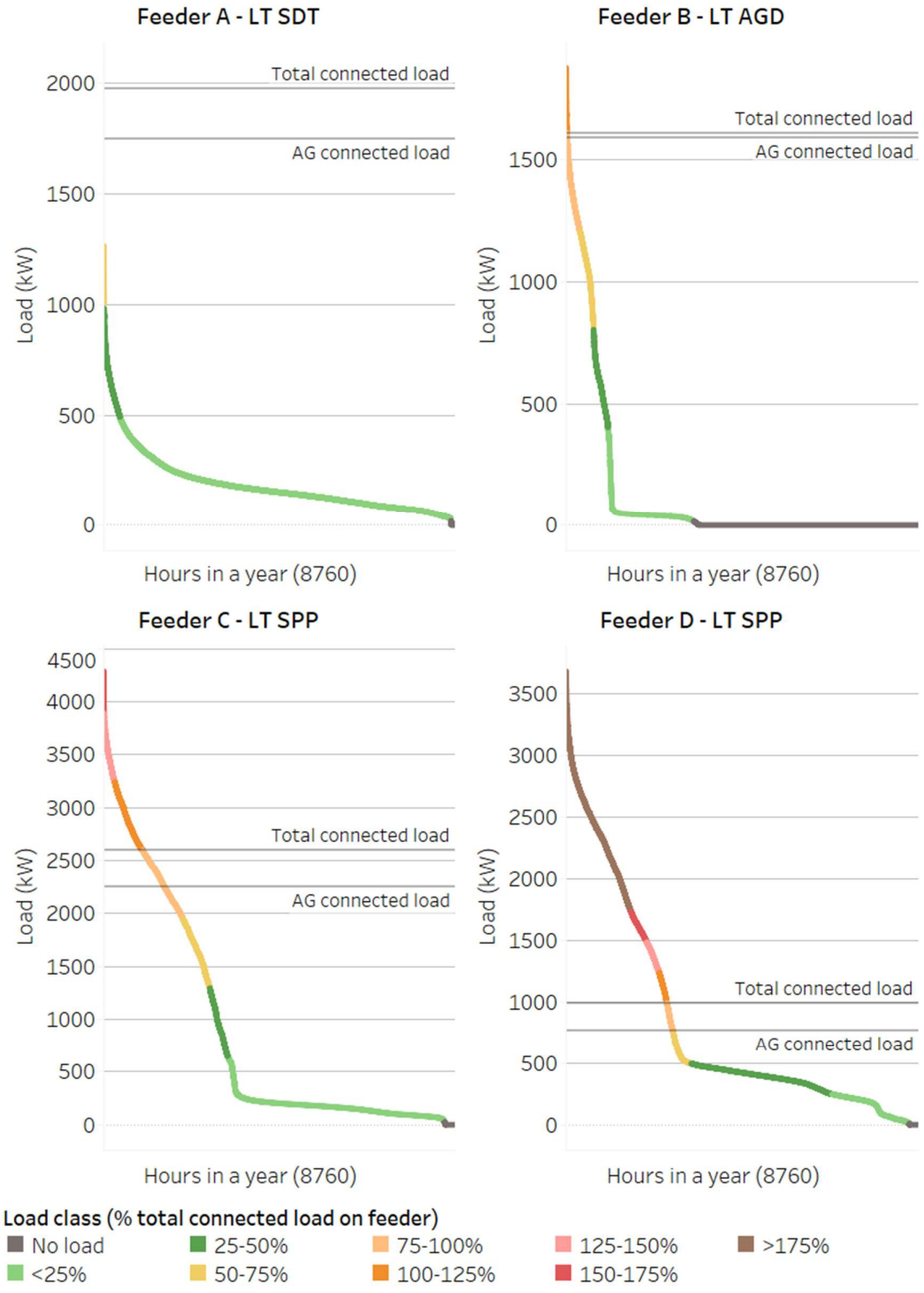
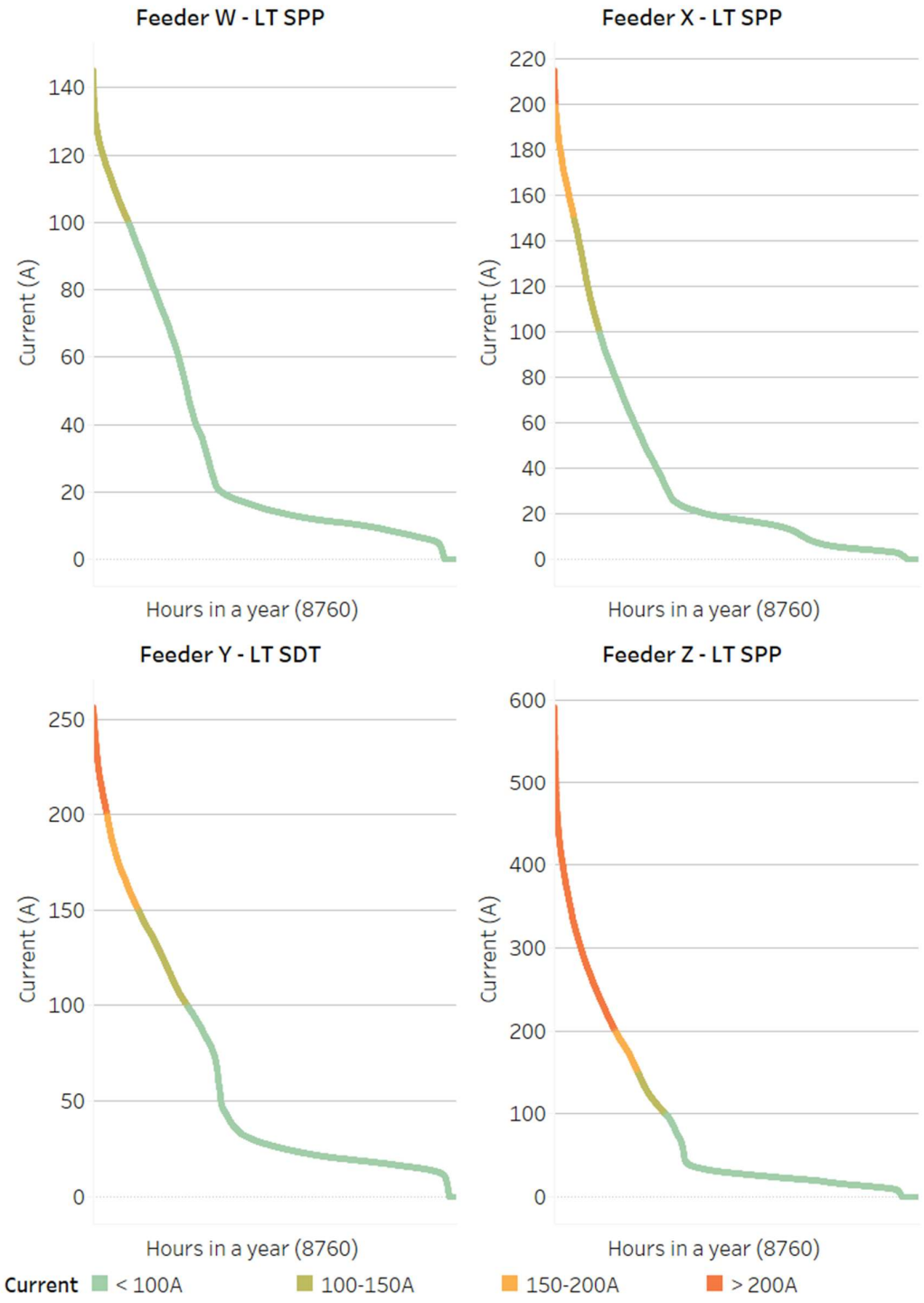


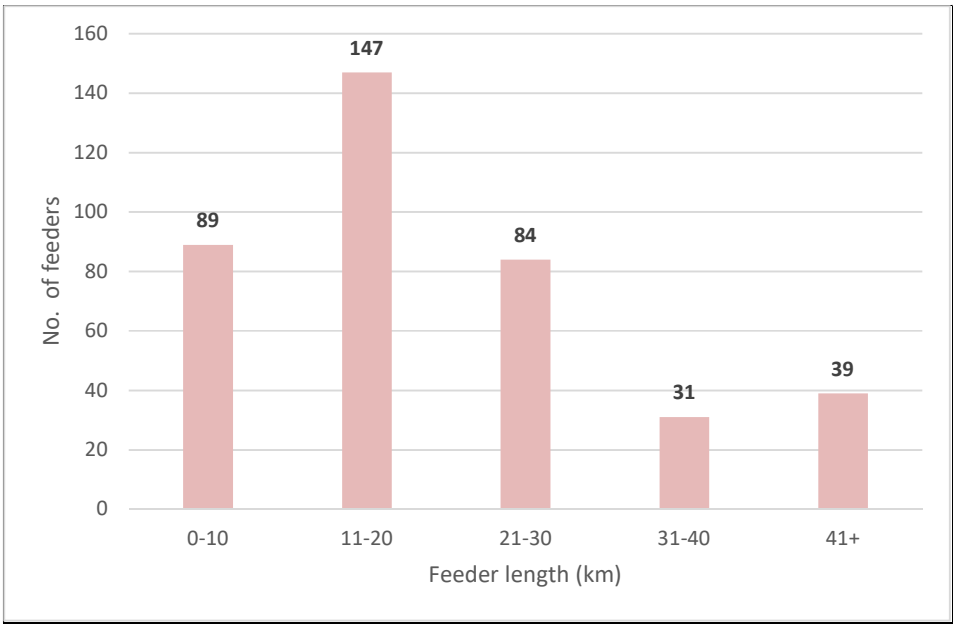
*Figure 5-2 Feeder loading profiles- Feeder Current Duration Curves*



## 5.4.Technical loss estimation

The methodology adopted by AGWG for estimating AG sales relies upon four crucial data sets which include non-AG sales, technical losses, feeder input, and AG connected load. Non AG sales and AG connected load data was obtained from MSEDCL billing database while feeder input was taken from AMR / MRI feeder meters. On specific inquiry regarding estimation of technical loss on AG feeders, MSEDCL stated that it has not carried out any such study and no estimate about technical loss on AG feeder is available. In the absence of any estimation of technical loss for AG feeders by MSEDCL, the working group was constrained to undertake indicative estimation of technical loss on AG feeders. Technical loss calculation requires information such as feeder length, conductor size, number of DTs, and year-round load profile of the feeder, etc. Such complete information was available only for 44 feeders out of 502 feeders. Out of these 44 selected feeders, similar to the load profile analysis presented in section 5.2, 29 feeders have registered excess loading (i.e. load more than the total connected load of the feeder). It is also observed that 45% of these feeders have lengths between 11 km and 20 km, while for 23% feeders, length exceeds 20 km. Out of a total sample of 502 feeders, feeder length was available for 390 feeders. Frequency distribution of the lengths of sample feeders as per Feeder Information provided by MSEDCL is presented below:

*Figure 5-3 Frequency distribution of AG feeders based on length of AG feeders*




For estimation of technical losses, three loss components are considered. These include 11 kV line loss, DT loss, and LV circuit loss. Based on actual, hour by hour feeder loading data, these

losses are calculated for five different loading conditions ranging from the excess load (load more than the connected load of the feeder) to very low load (load less than 25% of the connected load). Please refer to Annexure 4 for more details of the technical loss estimation methodology. This methodology was used to estimate technical loss for the purpose of interim report.

Based on these calculations, it was observed that technical losses in AG feeders range between 6%-24%, with a weighted average of these 44 feeders being 18%. Such wide variation in losses is observed primarily because of loading on the feeders and length of the feeders. For example, one feeder reported a technical loss of 24% as it runs 29 km and had significant excess loading (241 Amp) for the duration of around 180 hours, while another feeder runs only 9 km and no excess loading was observed, resulting in a loss of just 6%. Further analysis was carried out to ascertain quartile-wise % losses. Each feeder out of 44 feeders was assigned a weight equal to the ratio of feeder input to the sum of feeder inputs for the respective quartile. Quartile wise % losses were then derived and have been tabulated below:

*Table 5.4 Quartile-wise technical loss estimation*

| Quartile | Estimated technical losses (%) |
|---|---|
| 1st | 19% |
| 2nd | 19% |
| 3rd | 16% |
| 4th | 11% |

Subsequent to WG estimating technical losses, MSEDCL submitted that feeder technical loss levels estimated by AGWG seem to be very high and estimated that based on its analysis "From detail calculation of 37 feeders, the Technical Loss is in the range of 1.55% to 5.02 %. With addition of 3% losses accounted for deteriorated lines due to aging, joints on HT/LT lines, repaired DTCs and non-ideal field conditions, the technical loss of feeder can be considered as 8%." Review of MSEDCL loss estimate indicated that out of 37 feeders considered by MSEDCL, for more than 25 feeders estimated losses (before allowance of 3%) are less than 4 %. Analysis also showed that for most of these feeders just DT losses account for over 60% of total losses on the feeder (i.e. HT line loss plus DT loss plus LT circuit loss). Table 5.5 provides more details about losses estimated by MSEDCL.

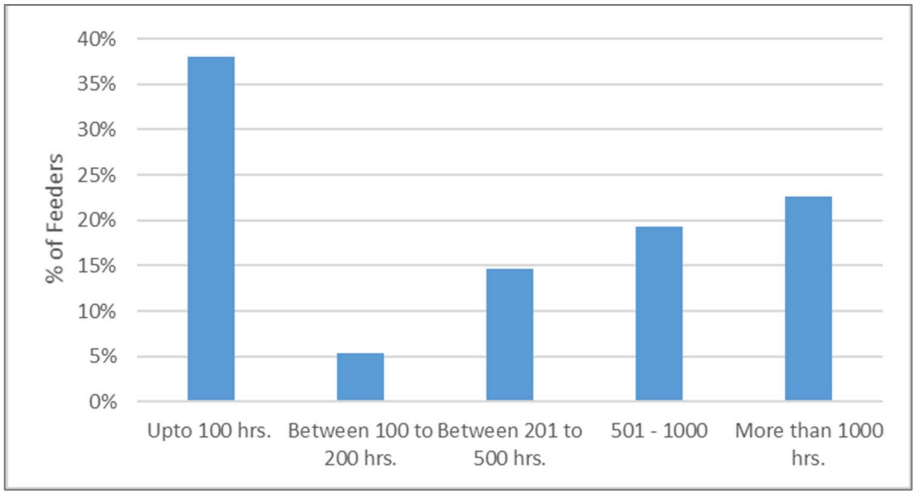
*Table 5.5 AG Feeder technical loss estimation by MSEDCL*

| for 37 feeders | HT LINE LOSS (%) | DTC LOSS (%) | LT LINE LOSS (%) | TOTAL LOSS (%) (before allowance for field condition) |
|---|---|---|---|---|
| **Overall** | 0.08% | 2.56% | 0.57% | 3.20% |
| **Average** | 0.08% | 2.65% | 0.56% | 3.29% |
| **Median** | 0.07% | 2.72% | 0.44% | 3.24% |
| **Min** | 0.01% | 1.25% | 0.07% | 1.62% |
| **Max** | 0.22% | 4.10% | 2.53% | 5.02% |

Also there seems to be some difference in basic data such as number of DTCs on selected feeders as submitted by MSEDCL earlier and as considered by MSEDCL in it's loss calculations. Considering all these factors as well as feeder loading pattern and feeder lengths mentioned in earlier sections of the report, MSEDCL estimate of feeder technical losses appeared to be very low and technically unrealistic. Subsequent to publication of interim report, WG had further interaction with MSEDCL. During the interaction, certain shortcomings were observed in the MSEDCL methodology and MSEDCL agreed to rectify the same. Revised MSEDCL adopted methodology is similar to the one presented in Annexure 4, but uses more granular data, with consideration of 20 current loading slabs, each DT loading in proportion to DT capacity and uses actual HT line layout. MSEDCL was asked to submit revised technical loss estimation for same 37 feeders. MSEDCL provided revised calculations for only two feeders. As per this revised calculation using corrected methodology, HT line loss component has increased 20 and 80 times, and LT line loss has increased 2 to 17 times, with total feeder loss being twice that of earlier estimate. Thus for these two feeders total losses work out at 8.2% and 9.6% (with allowance for field conditions). These feeders are relatively short feeders (7 and 11 km) and moderately loaded feeders (current more than 100A for about 200 hrs. and 2 hrs. for these two feeders) compared to other feeders in 502 sample feeders. For example, as depicted in earlier chart in this section, out of total 390 feeders for which information was available only about 22% feeders have length less than 10 km, while 37% feeders have length between 11-20 km and 40% have length more than 20 km. Similarly as depicted in Figure 5.3 earlier (feeder length) and below Figure 5.4 (current distribution) , peak current as well as duration of high current (say more than 100 A) is

much more in most of the feeders under study, than in case of two sample feeders for which MSEDCL has worked out revised loss estimates. All these data indicate that technical losses on AG feeders would be much more than earlier estimate by MSEDCL. In order to assess implications of different technical loss levels on AG sales estimation WG carried out sensitivity analysis considering loss levels of 14% , 16 % and 18%.

*Figure 5-4 Feeder loading pattern[3] – Current more than 100 A*

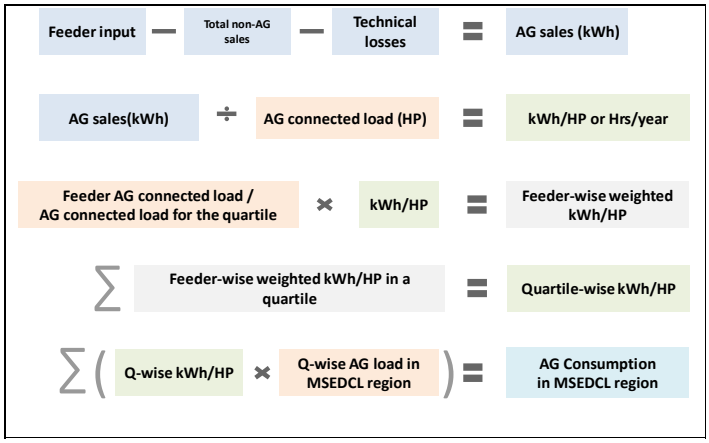



[3] Based on feeders with more than 90% slot-wise data availability.

# 6. Estimation of Agricultural Consumption for FY 2018-19

As mentioned in chapter 3, sample of 502 feeders was selected for estimating AG consumption. MSEDCL was required to undertake correction of consumer mapping for these feeders to ensure that actual number of AG and non-AG consumers, their connected load, DT wise updated consumer list is verified. MSEDCL claimed to have undertaken such an exercise and provided updated / post-mapping consumer data for all 502 feeders. This data was used for calculating feeder wise AG consumption norm along with AMR / MRI meter-based feeder input data. AMR / MRI data for these feeders was sought from MSEDCL. This data includes 30-minute slot wise load profile data and cumulative energy meter reading data on monthly basis. Load profile data consists of feeder line currents, voltages, active energy and multiplication factor for meter. For estimating AG sales for FY 18-19, steps described in chapter 3, and reproduced in figure 6.1 here, were followed.

*Figure 6-1 Overview of AG consumption estimation methodology*




It was expected that complete AMR / MRI data for full year would be available for all sample feeders. But analysis of actual data revealed that feeder meter data for many feeders was not complete. For estimation of AG sales, considering large seasonal variation in AG consumption, it is important to consider full year data. Hence out of these 502 feeders, feeders with good quality full year data were shortlisted for further analysis. For this purpose, feeders with same feeder meter number for all readings, constant multiplying factor and cumulative energy reading spanning at-least 360 days of FY 18-19 were selected. It was further observed that out of this subset few feeders showed negative AG sales after deducting non-AG sales and estimated technical losses from feeder input. This indicated that either consumer mapping or feeder meter reading or non-AG sales were inaccurate. Hence such feeders were also excluded from further analysis. After this process 386 feeders were found to have consistent data for most required

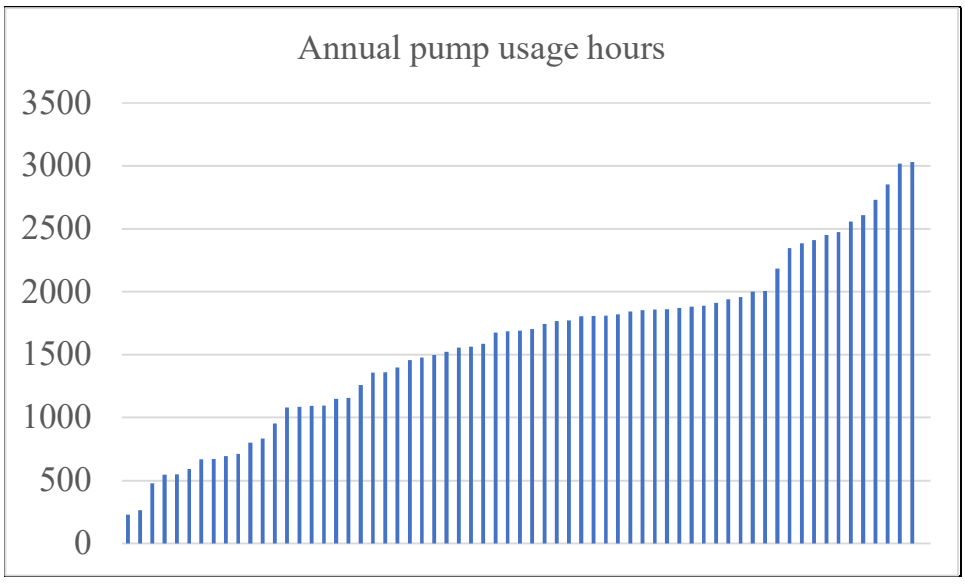
parameters and were selected for further analysis. These 386 feeders were also found to be spread across four quartiles in similar proportion as full sample of 502 feeders. In the next step, for this subset of 386 feeders, feeder-wise AG consumption (in kWh) was calculated by subtracting non-AG sales and feeder losses from metered feeder input[4]. This was then used to calculate feeder wise consumption norm / index, in kWh/HP/yr. and hrs./HP/yr. by dividing AG consumption by total AG connected load on the feeder as per MSEDCL billing / master data. **This has two implications. One, all AG connections as per MSEDCL database are considered as active and two, consumption due to any excess load (larger size pumps than authorised connection) is also considered in sales estimation.** AG consumption index thus calculated for 386 feeders showed wide variation with some feeders having clearly irrational consumption norm. For example, some feeders show annual pump operating hours less than 100 hrs, while some feeders showed annual operating hours in excess of 8760 hrs. (i.e. more than total hours of the year) and in 7 cases more than even 12,000 hrs. This again indicated that either consumer mapping or feeder metering or non-AG sales on these feeders is incorrect and such outliers need to be excluded. Examples of frequent data changes and discrepancy discussed later in this section also substantiates likelihood of significant errors in consumer mapping, and need for applying appropriate filters to exclude outliers. For this it was decided to apply lower and upper cur-off of annual hours of operation for identifying such outliers. **Non application of filter would result in double counting of AG consumption due to wrong mapping. This is because consumption of such wrongly mapped pumps gets accounted in feeder input and increases feeder index, which is multiplied by total MSEDCL AG connected load, which again includes such wrongly mapped load.**

Analysis of AG consumer survey, (refer chapter 4) indicated that 98% AG consumers use pumps for less than 1500 hrs. / year, of which about 20 % use pumps for less than 300 hrs. a year. This survey also indicated that more than 98% AG consumers use pumps for less than 250 days a year, of which about 6% use pumps for less than 50 days a year. Assuming 10 hrs./ day of 3 phase supply, which is consistent with AG supply protocol of MSEDCL, maximum annual hours of operation would be 2500 hrs. for pumps used for 250 days a year. MERC as well as MSEDCL have in the past used 3000 hrs./ yr. as upper cut-off for identifying outliers while estimating AG consumption. For example, **MSEDCL in it's communication to WG dt. 27 May 2019, stated that in the sales estimation methodology adopted by MSEDCL, it used upper filter of 3000 Hrs./ year, based on consideration of maximum 300 days of pump usage and daily 3 phase supply of 10 hours.** Besides, applying cut-off for operating hours at pump level and that at feeder level are

[4] For this analysis feeder loss of 16% and 20% was considered. Refer section 5.4 for more discussion about feeder loss estimation.

distinct aspects. Applying cut-off of 3000 hours of operation at feeder level actually means all pumps on the feeder if operating for 3000 hours are also covered. WG also analysed feeder input data to assess appropriate upper cut-off. For this analysis, feeders meeting following three criteria were selected, i) AMR / MRI slot wise load data is available for more than 90 % slots of the year, to cover feeder loading in all agricultural seasons, ii) feeders where MSEDCL has not claimed any assessed energy, i.e. 100 % feeder input is recorded in meters, to avoid any feeder metering issues, and iii) feeders which have recorded maximum load upto 200% of total connected load on the feeder. Considering maximum load upto 200% of total connected load imply that consumption due any excess load (either due to wrong mapping, or due to use of larger pump size then authorised or theft) upto 100 % of connected load, would be covered. Considering the implications of wrong mapping and excess loading on computation of feeder index as highlighted above, criteria of maximum load upto 200% of total connected load is quite liberal. Figure 6.2 depicts annual hours of operation for 65 feeders which met these criteria. As can be seen from this chart, for all feeders with reliable metering data and reasonably correct mapping or limited un-authorised load, maximum hours of pump usage are 3000 hr./ per year. Hence, from this analysis also, it is clear that 3000 hrs./ yr should be the filtering criteria for maximum hours of operation.

*Figure 6-2 Annual pump usage hours on select feeders*




In interim report, four combinations of lower and upper cut-off hours were considered. These are shown in table 6.1. Also, two different feeder loss values of 16 % and 20% were considered. Thus, total eight scenarios were considered for estimation of MSEDCL AG sales for FY 18-19.

*Table 6.1 Cases considered for sensitivity analysis of AG sales estimation*

| | **Hours / Year** | | **Feeder loss considered for sensitivity** |
|---|---|---|---|
| Case | Lower Cut-off | Upper Cut-off | % technical loss |
| **1** | 300 | 2500 | 16 % and 20 % |
| **2** | 500 | 2500 | 16 % and 20 % |
| **3** | 300 | 3000 | 16 % and 20 % |
| **4** | 500 | 3000 | 16 % and 20 % |

For each of these scenarios, AG sales for MSEDCL were estimated using the methodology explained in section 3.4. As per MSEDCL submission to MERC, total MSEDCL AG LT load for FY 18-19 is considered as 215 lakh HP, which covers the entire population of agriculture connected load as per records of MSEDCL and not just the load on AG dominant feeders. This resulted in MSEDCL's LT AG sales to be in the range of 21,000 MU to 23,800 MU. Based on this in the interim report, WG recommended FY 18-19 AG sales at 22,859 MU.

Apart from the issue of technical loss estimation, (which has been addressed in earlier section) and application of upper cut-off, (which is also dealt above) MSEDCL in it's submission on interim report commented that i) WG should consider feeder data submitted on 21 Nov. 2019, instead of data submitted on 24 Oct. 2019 which was considered in the interim report, and ii) WG has not considered assessed energy input for 181 feeders. These issues are discussed below.

Frequent variation in available data from MSEDCL has been a major challenge that AGWG had to deal with before taking it for further analysis. After selection of sample feeders, Working Group had repeatedly asked MSEDCL to verify consumer and DT mapping and to provide updated / corrected data to WG. MSEDCL provided these data on 24 Oct. 2019 and the same was used for calculations in the interim report. Just to illustrate how frequently data changes, Table 6.2 compares feeder input as per 21 Nov. 2019 data, which as per MSEDCL is correct data and data submitted by MSEDCL on 4$^{th}$ March 2020 with justification / reasoning for assessed energy on 181 feeders. Feeder input in both cases is inclusive of assessed energy. Major reasons provided for assessed energy were, meter calibration issues (about 35 out of 181 feeders) and issues related to CT / PT (in case of over 70 feeders).

*Table 6.2 Comparison of feeder input*

| Feeder Name | Feeder input as per 21 Nov 2019 (kWh) | Feeder input as per 4 March 2020 (kWh) | % increase over 21 Nov 2019 data |
|---|---|---|---|
| 11 KV UMRAD AG | 6295376 | 7602287 | 21% |
| 11 KV MUNGI AG | 4292089 | 5188951 | 21% |
| 11 KV TAKARKHED AG | 4966410 | 6519820 | 31% |
| 11 KV NANDWEL | 12542080 | 16704800 | 33% |
| Umbri AG | 3717040 | 5052960 | 36% |
| PARITE AG | 5722670 | 8008193 | 40% |
| Bemble AG | 4198371 | 7111399 | 69% |
| Padali Ale AG | 3535480 | 6647960 | 88% |

Another example of frequent data changes and discrepancy is depicted in Table 6.3 below. Large variation is seen in number of DTs and number of AG consumers in data submitted within just 3 days gap.

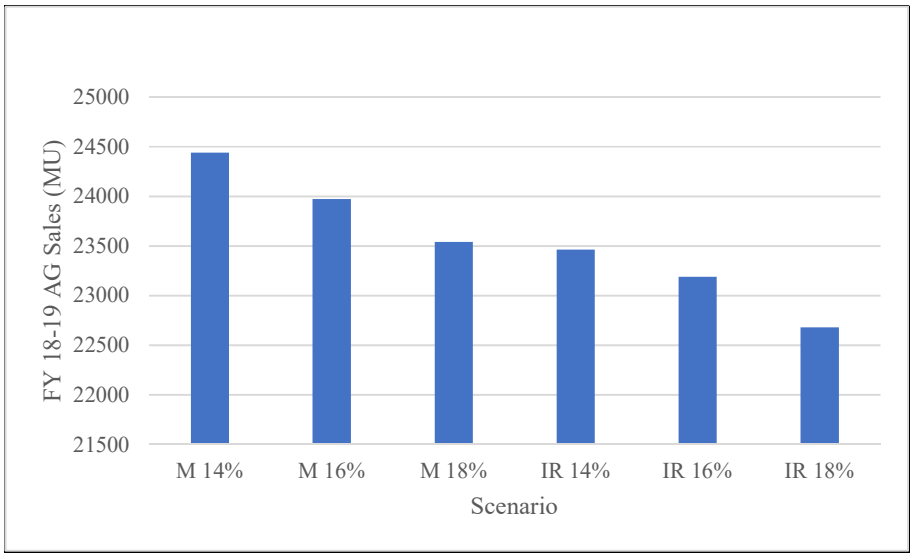
*Table 6.3 Example of data discrepancy – number of consumers and DTs*

| | Number of DTC | Number of AG Consumers |
|---|---|---|
| **Feeder A** | | |
| Data uploaded for survey on 18 Nov. 2019 | 18 | 348 |
| Data submitted on 21 Nov. 2019 | 31 | 305 |
| **Feeder B** | | |
| Data uploaded for survey on 18 Nov. 2019 | 36 | 1038 |
| Data submitted on 21 Nov. 2019 | 46 | 903 |
| **Feeder C** | | |
| Data uploaded for survey on 18 Nov. 2019 | 29 | 543 |
| Data submitted on 21 Nov. 2019 | 44 | 543 |
| **Feeder D** | | |
| Data uploaded for survey on 18 Nov. 2019 | 17 | 597 |
| Data submitted on 21 Nov. 2019 | 58 | 651 |

Nonetheless, even though there is significant divergence in data submitted by MSEDCL at different times, WG decided to undertake analysis using dataset as finally suggested by MSEDCL to assess implications of different base data. This include AG load and Non AG sales as per data submitted on 21 Nov 2019. Feeder input for 181 feeders as per latest submission, dt. 4 March 2020, which also include assessed energy for these feeders. For remaining feeders, feeder input as per data dt. 21 Nov. 2019 is considered. This is called scenario M_502_181. Figure 6.3 below depicts AG sales estimation for two scenarios – M_502_181 and IR_386, which is as per dataset used for analysis in interim report. For each scenario, sensitivity analysis is

carried out for 14 %, 16 % and 18% AG feeder technical loss. Based on the analysis in this section, and as per final scenario considered in interim report, lower cut off of 300 hrs and upper cut-off of 3000 hrs. has been considered for all these scenarios.

*Figure 6-3 FY 18-19 AG Sales under different scenarios*




| Scenario | M_502_181 | | | IR_386 | | |
|---|---|---|---|---|---|---|
| Losses | 14% | 16% | 18% | 14% | 16% | 18% |
| Name | M 14% | M 16% | M 18% | IR 14% | IR 16% | IR 18% |

**This analysis, using different datasets and technical loss values, indicate that for FY 18-19, LT AG sales of MSEDCL were in the range of +/- 4% of 23,500 MU, and hence, 23,500 MU should be used for any specific analysis and energy balance as well as distribution loss calculations for MSEDCL system.**

Based on various analysis presented in the preceding chapters of this report, the Working Group estimates FY 18-19 LT Agricultural Sales of MSEDCL to be 23,500 MU. This corresponds to agricultural consumption norm of 1,093 kWh/HP/yr. or 1,465 hrs./ yr.

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# 7. Conclusions and Way Forward

Field survey carried out as part of the working group study has clearly brought out the limitations and status of AG consumer metering on field. **The analysis of AG metering status based on field survey of nearly 1.33 lakh consumers spread across the state shows that compared to utility records, meters are present for only 27% metered AG consumers. Further in cases where meter readings could be validated, more than 50% readings were found to be incorrect. This highlights significant challenges in metering agricultural consumers.** In the absence of consumer metering, it is inevitable that AG sales will have to be estimated based on some other parameters, and as estimation methodology evolves, assessment of AG consumption would also evolve. This is also observed in review of AG sales estimation practices in few states undertaken by the working group. Feeder meter-based analysis, as considered in this report, enables capturing consumption of large number of AG consumers in an economical, efficient and reasonably accurate manner. For example, sample 502 feeders considered in this study covered total of about 2.3 lakh AG consumers (i.e. more than 5% of total AG consumers of MSEDCL). Based on field survey it is certain that ensuring reasonably accurate metering of AG consumers is going to take some time and AG sales will need to be estimated for few more years. Hence, it is important to continuously improve reliability of such estimation, by ensuring correct consumer mapping, reliable and accurate feeder metering, identification of missing / defunct AG connections and restating total AG connected load to that extent. **Analysis carried out by the WG also indicate that even technical losses on AG feeders may be far higher than expected. This could be due to feeder loading pattern, large number of DTs on AG feeders and feeder length. It would be helpful for MSEDCL to undertake thorough analysis of technical loss on AG feeders. This will help better identification of distribution losses and plan infrastructure investment to reduce distribution loss.** The feeder meter-based method would enable year on year estimation of AG sales. Such an estimation would also capture changes in AG sales due to factors such as change in rainfall, cropping pattern, and electricity supply hours, as effect of these parameters on pump usage will be captured in feeder input and hence feeder meter readings.

A similar exercise, covering more number of feeders for feeder meter analysis and more focused, limited sample for field validation, could be undertaken at the beginning of each MYT period to assess agricultural consumption, and inter-alia distribution loss for the last year of previous MYT period. This distribution loss could be used as reference for final true-up of previous MYT period as well as for providing distribution loss trajectory for ensuing MYT period. This would enable capturing dynamic nature of AG consumption on periodical basis. For the purpose of mid-term review and provisional true-up on yearly basis, a limited exercise of feeder meter based analysis

could be carried out at the time of mid-term review exercise. Improving consumer mapping and AMR based feeder metering would help cover larger number of feeders and would also improve accuracy of estimation.

**Based on extensive analysis carried out by the WG, FY 18-19 LT AG sales of MSEDCL are estimated to be 23,500 MU. This is about 70% of sales estimated by the utility, and would imply distribution loss of around 22 %, a difference of around 7.3 % points compared to 14.7 % as claimed by MSEDCL for FY 18-19.** It needs to be noted that this difference in distribution loss is a result of better estimation of AG sales that was possible due to improved feeder metering undertaken in recent years and MERC's consistent emphasis, since 2011, to undertake third party independent estimation of AG sales. Distribution losses in earlier years are also likely to be at least at the level of FY 18-19 losses, but could not have been accurately estimated in the absence of detailed exercise as carried out by the working group. Recognising this, the commission has already provided dispensation regarding treatment of difference in distribution losses in it's order in case no 195 of 2017, dated 12 September 2018. This is reproduced below.

*"3.2.34. The Commission would undertake a detailed review of the methodology of determination of AG Sales based on the Study proposed to be carried out by the Commission through a third party agency appointed. The methodology finalised through this study shall form the basis for approval of AG sales during truing up exercise to be carried out at the end of the 3rd Control Period and for years FY 2014-15, to FY 2016-17. However, it is clarified that as the true-up of ARR for these years is already over (except for the assessment of AG sales and corresponding revision in the distribution loss thereof (if any)), the revision of revenue gap (over-recovery or under-recovery) shall be undertaken only in terms of sharing of distribution loss. For this purpose of sharing of gains/losses same methodology and principles as adopted through this MTR Order for respective years shall be followed for such adjustment."*

This dispensation addresses the issue of impact of restatement of AG sales on MSEDCL and consumers. In addition to consumer tariff, Government of Maharashtra also provides subsidy to reduce agricultural tariff. This subsidy is based on connected load (HP) of un-metered AG consumers and sales to metered consumers. This subsidy is provided on the basis of gross numbers and not to any specific individual. Restatement of AG sales to 70% of earlier estimates implies that on per unit basis Government subsidy towards agricultural consumption was in fact more. In the absence of such subsidy, entire burden of additional losses (except loss reduction target of typically 1% to 2% points) would have fallen on MSEDCL consumers and average tariff would have increased. Thus, even though AG sales are restated, government subsidy calculated on the basis of earlier estimates, has helped reduce burden of excess losses, cross-subsidy as well

as tariff for all consumers of MSEDCL. Being regulated entity MSEDCL cannot make any profit out of such subsidy amount.

Field survey undertaken by the WG revealed that meters are present for only 27% of AG metered consumers. As such there is a need for alternative mechanism to bill such consumers. For this, MSEDCL should update metering status in its systems based on actual field conditions. There are two possible options for billing consumers without meters. One, for the duration of missing meters and till meters are installed, such consumers could be applied HP based tariff that is applicable to about 15 lakh un-metered consumers. Second option is to charge such consumers at the average AG consumption index for the state, i.e. 1,093 kWh/HP/Yr. These options would address immediate issues, but different options need to be explored for long term solution. Commentators on interim report suggested that feeder input based AG billing should be undertaken. Under this scheme, all consumers on particular feeder will be billed for total AG consumption on that feeder. AG consumption would be calculated as feeder input less Non-AG sales less technical loss. Total AG consumption on the feeder would be divided amongst all AG consumers on that feeder in proportion to connected load (HP) of each consumer. This approach would lead to consumers paying bills based on their consumption and consumers on feeders with low consumption would pay less bill. This would also encourage accountability for feeder metering and may reduce un-authorised consumption, as all authorised consumers on the feeder will have to pay for that. Wide scale adoption of this method would depend on MSEDCL's preparedness in terms of ensuring accurate feeder metering, ability to estimate technical loss and correcting consumer mapping. MERC may consider allowing this methodology initially on pilot basis in few areas and then depending on experience of the same, decision regarding state-wide application of the same could be made. In this process care should be taken that adequate transparency, and accountability mechanisms are built into the scheme. Also, option of individual consumer metering need to co-exist with this approach. AG metering and billing is a challenging issue and WG believes that there is a need for experimentation and different options need to be tried out. These options should encourage consumption based metering and billing in an efficient and practical manner. Different options may also be considered for different regions to account for regional variation in cropping pattern, metering, billing and payment history etc. To this effect MSEDCL may consider proposing different pilot projects for AG metering and billing. MERC may consider allowing such options during current MYT period and depending on the field experience most viable options could be adopted for large scale implementation in the next MYT period.

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# 8. Annexures

## 8.1. Annexure 1: MERC Notification– Constitution of Working Group for Agricultural Consumption Study

**Before the**

**MAHARASHTRA ELECTRICITY REGULATORY COMMISSION**

**World Trade Centre, Centre No.1, 13th Floor, Cuffe Parade, Mumbai 400005**
**Tel. 022 22163964/65/69 Fax 22163976**

**Email: mercindia@merc.gov.in**

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**Date 2 November, 2018**

**Constitution of Working Group for Agriculture Consumption Study**

1. Mid-Term Review (MTR) Order for MSEDCL was issued on 12 September, 2018 in Case No. 195 of 2017. In the said Order, as regards assessment of Agricultural sales the Commission has ruled as under:

> *"3.2.32. In the previous MYT order, the Commission had disallowed 2,414 MUs of AG sales in FY 2014-15 and 3,400 MUs of AG sales in FY 2015-16. In the MTR Petition, MSEDCL has requested the Commission to approve the AG sales for FY 2014-15 and FY 2015-16 without any disallowances. In the review order Case No. 176 of 2016, the Commission had decided to revisit the disallowances in the MTR Petition on the basis of statement by MSEDCL that the Committee report is expected by March, 2017. However, the Commission notes that MSEDCL has not yet submitted the report as elaborated earlier in this section.* ***Hence, the Commission now shall conduct an independent study through an agency for assessment of Ag sales, which shall form the basis of establishment of Ag sales from FY 2014-15 and in subsequent years. The Commission shall appoint an independent 3rd party agency to undertake such study. Further the Commission shall define a detail ToR in due course of time and would be published on website.:" (Emphasis Added)"***

2. Now, the Commission has accorded approval for constitution of the Working Group for Agricultural Consumption study. Details of Working Group is as follows:

**2.1.** Constituents / Members of Working Group:

- **a.** Executive Director / Director, MERC – Convener
- **b.** Prayas (Energy Group), Pune – Member
- **c.** Idam Infrastructure Advisory Pvt. Ltd., Mumbai – Member
- **d.** Survey Agency / Agencies (to be appointed) – Member
- **e.** Representative of MSEDCL – Special Invitee

**2.2.** Objective:

- **a.** To ascertain AG consumption norm (units/HP/annum and/or hours/HP/annum) for different region/districts/zone/circles within Maharashtra based on approved sampling methodology
- **b.** To verify and validate metered AG consumption for select sample feeders based on sample survey and methodology to be formulated
- **c.** To devise methodology for verification and validation of AG consumption based on feeder AMR data.
- **d.** Based on assessment of AG Consumption Norm, devise the methodology for ascertaining the AG Sales for FY 2014-15 to FY 2017-18.
- **e.** To evolve methodology and formulate procedure for measurement and estimation Agricultural sales for future period.

**2.3.** Responsibility of each Constituent/ Member of the Working Group:

**a.** Terms of Reference for Executive Director, MERC –Convener**:**

i. Coordinating with Members of Working Group and MSEDCL.
ii. Monitoring timelines and take corrective steps
iii. Arrange to resolve difficulties faced by Working Group Members / Survey Agencies in undertaking Study.
iv. Preparation of Survey Questionnaire jointly with other Working Group Members
v. Any other work which is important for successful completion of Study.

**b.** Terms of Reference for Prayas (Energy Group) – Member:

i. Finalization of survey methodology, finalization of approach for data analysis and approach for monitoring/ verification and reporting framework.

ii. Identification of sample feeders, finalization of sampling methodology and sample size
iii. Preparation of Survey Questionnaire jointly with other Working Group Members
iv. Independent analysis and validation of data and key findings presented by Survey Agency during Monthly/Quarterly progress review meetings of Working Group
v. Development methodology for validation of findings through Secondary Research/Data sources
vi. Development of Templates for data collation and Report preparation for Study Group
vii. Any other work which is important for successful completion of Study

**c.** Terms of Reference for Idam Infrastructure Advisory Pvt. Ltd. – Member:

i. Identification of sample feeders, finalization of sampling methodology and sample size
ii. Finalization of survey methodology, finalization of approach for data analysis and approach for monitoring/ verification and reporting framework.
iii. Preparation of Survey Questionnaire jointly with other Working Group Members
iv. Verification and validation of data analysis and key findings presented by Survey Agency during Monthly/Quarterly progress review meetings of Working Group
v. Highlighting the gaps / limitations upon verification of data/analysis presented by Survey Agencies
vi. Methodology adopted in 4-5 adjoining similarly placed states to the extent information available in public domain
vii. Any other work which is important for successful completion of Study

**d.** Terms of Reference for Survey Agencies – Member:

i. Participate in Working Group discussions for finalization of survey methodology & representative sample size giving due consideration to the timeframe
ii. Preparation of Survey Questionnaire jointly with other Working Group Members
iii. Undertaking field survey as per methodology to be agreed in

consultation with Working Group

iv. Undertaking data analysis / Presenting findings during Monthly/Quarterly and final progress review meetings of Working Group
v. Preparation of Survey Report and findings for the selected area under study
vi. Sharing of data in the prescribed form/formats using IT tools for further analysis.
vii. Support in extrapolation of the findings from sample to region to State with highlighting limitations, if any.
viii. Support in preparation and finalization of the Report of the Working Group
ix. Any other work which is important for successful completion of Study

**e.** Support from MSEDCL – Special Invitee:

i. Provide data required by the Working Group. MSEDCL should identify Single point source at Senior Level for this purpose
ii. Provide support to Survey Agencies for field survey including followings:
    1) Ensures that meters and allied measuring equipments of selected Feeder/ DTC are working correctly.
    2) Depute Field Staff to assist the survey agency in identifying Feeder / DTC / Ag consumer.
    3) Provide help, if required, to Survey Agency in collecting data / taking readings.
iii. Provide IT Tool and Data Repository support

Any other work which is important for successful completion of Study

**2.4.** Timeline - Final Report to be submitted by January/February, 2020.

3. The Commission is in the process of appointing Survey Agency (one or more).

4. First Meeting of Working Group was held on 30 October, 2018.

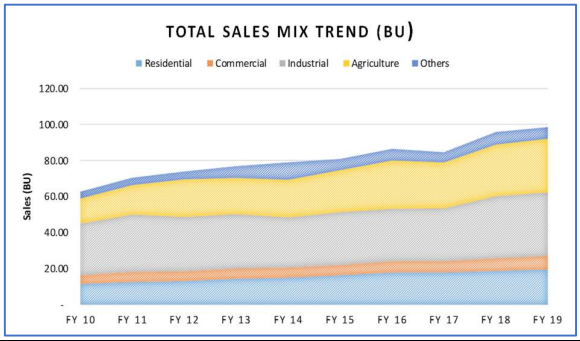
Sd/- Secretary, MERC

## 8.2. Annexure 2 : Review of regulatory methodologies/practices followed in select states for agricultural consumption estimation

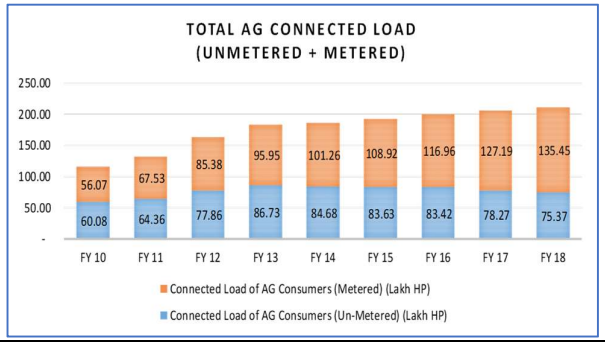
### 1. Maharashtra

Agriculture sales constitute around 30% of the total sales of the MSEDCL. Number of AG consumers have increased by over one & half times from 27.5 Lakh to 42 Lakh over past decade. Share of Metered to Un-metered Agriculture consumers constitute around 62:38. Total connected load of agriculture consumers in the system has almost doubled from 116 Lakh HP to 219 Lakh HP over the same period whereas reported AG sales has increased by over two times from 13.4 BU (FY10) to 29.6 (FY19). Historical trend of the number of consumers, connected load and sales of agriculture consumers is presented in the following graphs:

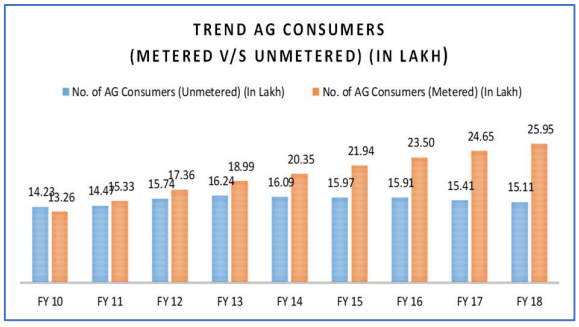
Historical Trend of total sales (Billion Units)



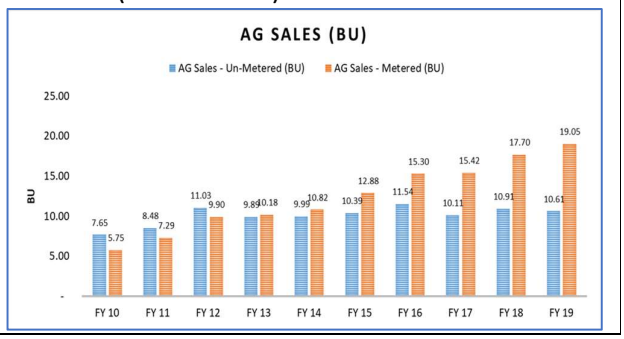

No. of AG Consumers (Lakh)




AG Consumer Connected Load (Lakh HP)




AG Sales (Billion Units)




(Source: MERC ARR/Tariff Orders for respective years)

Methodology adopted by Commission for verification and approval of the AG sales has evolved based on availability of data, sample information, zone-wise/circle-wise energy accounting/energy audit data, growth of metered/un-metered consumption/connected load information as furnished by the utility. The commission has undertaken scrutiny/verification of the information for prudence check and approval of AG consumption index for the reported

period and elaborated its rationale/limitations for estimation of AG Sales as considered under the respective Orders issued from time to time:

**(A) Applicable period: FY 1999-2000 to FY 2000-01**

*Reference Order: Case No. 1 of 1999 dated 5 May, 2000*

- LT agricultural pump sets are supplied electricity on a flat rate basis as consumption is not metered. Hence, Commission considered it appropriate to verify and ascertain and un-metered consumption.
- MSEB's agricultural consumption norms are based on a sample **study of 1,582 agricultural feeders since 1997-98**. The MSEB has submitted that, of these 1,582 feeders, **readings of 192 feeders,** spread out over **various zones of the State, appear consistent**.
- Thus, the average consumption of these agricultural pump sets be used as the basis for setting norms for the State as a whole.
- The Commission accepted the logic provided by MSEB and determined the AG consumption for LT AG pumpsets based on the following parameters:
    - Total AG Connected Load for (0-5 HP) & (5 HP to 10 HP)
    - Converting the HP Load into equivalent kW
    - Average AG consumption hours/annum separately approved for 0-5 HP Pump-sets and 5-10 HP Pumpsets
    - AG Sales (MU) = Load in kW x Average no. of AG consumption (or supply) hours/annum (~1600 hours/HP/annum)

**(B) Applicable period: FY 2001-02 to FY 2004-05**

*Reference Order: Case No. 1 of 2001 dated 10 Jan, 2002*

- The Commission in order to get more reliable **Ag Operating Hrs/HP/Annum**, further decided to modify the consumption norms by **filtering the Feeders Circle-wise** based on the **Energy audit data** provided by MSEDCL.
- The Commission considered only those Feeders whose **recorded operating hours** was available for **more than 300 days**.
- Rationale for setting 300 days was more on account of considering the seasonal variations in consumption pattern.
- It was evident from the circle-wise summary, the **average operating hours per HP per annum** varies from **719** (for Osmanabad circle) to **1781** (for Bhandara circle).

- Based on the analysis of the data furnished, it can be deduced that the **average operating hours per HP per annum** for LT- agricultural consumption on aggregate basis works out to **1244 hours per HP per annum**.
- Thus, the Commission reinstated the operating norm for LT AG Pump-sets as **1250 Hrs/HP/Annum** as that of **1600 Hrs/HP/Annum** approved in the previous Order in Case No. 1 of 1999.
- However, the **sample size available** for analysis covers only **33,066 HP** of connected load which corresponds to **only 0.4% of total connected load** of **78,08,704 HP** reported under LT- agriculture category for 2000-01.

**(C) Applicable period: FY 2005-06 to FY 2014-15**

*Reference Order: Case No. 54 of 2004 dated 20 Oct, 2006*

- The Commission **revisited the methodology** of estimation of unmetered agricultural consumption from FY 2006-07 and decided to rely only on recorded consumption of metered consumers for estimating agricultural consumption.
- For analysis, the Commission sought the **Zone wise Metered Consumers Billing Information** and further **filtered it with the abnormal records**, viz., zero connected load, average billing, negative consumption, high connected load, etc., for all the zones.
- **After filtering out the abnormal cases**, the billing details of about **5 Lakh consumers comprising of 24 Lakh bills** have been used for arriving at the **Zone wise consumption norm** in **hrs/hp/annum**.
- The Commission used the zone wise consumption norm, arrived from recorded consumer metering information, for estimating unmetered consumption of that particular zone as well.
- Based on the zone wise consumption norm and connected load, the Commission worked out the consumption norm for the State **(1318 hrs/hp/annum)**, which was used only for the purpose of tariff categorization and not for estimating agricultural consumption.
- With respect to estimation of total connected load, the Commission adopted the **average load per consumer** based on previous years data.
- After applying the zone wise consumption norm to the zone wise connected load the Commission computed the LT - agricultural sales projections for the respective years.

**(D) Applicable period: FY 2015-16 to till MYT Order**

*Reference Order: Case No. 48 of 2016 dated 3 Nov, 2016*

- MSEDCL reported a significant increase in the provisional AG sales in FY 2014-15 without any corresponding increase in the number of consumers or Connected Load. **(~23% y-o-y** increase of AG sales when Connected Load y-o-y increase is **only 4%,** so increase in **AG Index of 19%** need scrutiny)
- Commission analysed the **Circle-wise feeder input as well as metered and unmetered data** submitted by MSEDCL of the number of Agriculture consumers, Connected Load, assessment of Agriculture Index, Feeder-level energy input and Agriculture sales for FY 2014-15.
- For Feeders with **positive Distribution Loss** levels (i.e. **33 Circles covering 2528 out of 4178** Feeders), the AG Index was worked out as the ratio of the reported Energy Sales to the Connected Load (HP) on the Feeder.
- For Feeders with **negative Distribution Loss** levels (i.e. **12 Circles** covering **1650 out of 4178** Feeders), the AG Index was worked out as the ratio of Energy Input reported for the Feeder to the Connected Load (HP) on the Feeder
- Further, the Commission observed that "*the AG Sales arrived from the Circle-wise AG Index norm methodology as above is subject to the findings of the Report of the Agricultural Consumption Committee assisted by IIT Mumbai. The Commission would undertake a detailed review of the methodology of determination of AG Sales after the Report is finalized. However, until the findings of the study become available, the methodology adopted in this Order based on Feeder-based energy accounting shall form the basis for determination of the AG Index and assessment of Agriculture consumption.*"

**(E) Summary Statistics of AG Consumption (Maharashtra):**

| Particulars | FY 10 | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 | FY 16 | FY 17 | FY 18 | FY 19* |
|---|---|---|---|---|---|---|---|---|---|---|
| **No. of Consumers (Lakh)** | | | | | | | | | | |
| - Metered (MC) | 13.26 | 15.33 | 17.36 | 18.99 | 20.35 | 21.94 | 23.50 | 24.65 | 25.95 | 27.93 |
| - Unmetered (UMC) | 14.23 | 14.47 | 15.74 | 16.24 | 16.09 | 15.97 | 15.91 | 15.41 | 15.11 | 14.64 |
| **Total No. of AG Consumers** | **27.49** | **29.80** | **33.10** | **35.23** | **36.44** | **37.91** | **39.41** | **40.06** | **41.06** | **42.57** |
| **Connected Load (Lakh HP)** | | | | | | | | | | |
| - Metered CL (MC) | 56.07 | 67.53 | 85.38 | 95.95 | 101.26 | 108.92 | 116.96 | 127.19 | 135.45 | 145.63 |

| Particulars | FY 10 | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 | FY 16 | FY 17 | FY 18 | FY 19* |
|---|---|---|---|---|---|---|---|---|---|---|
| - Unmetered CL (UMC) | 60.08 | 64.36 | 77.86 | 86.73 | 84.68 | 83.63 | 83.42 | 78.27 | 75.37 | 73.48 |
| **Total AG Connected Load** | **116.14** | **131.89** | **163.24** | **182.68** | **185.94** | **192.55** | **200.38** | **205.46** | **210.82** | **219.11*** |
| **AG Sales (Million Units)** | | | | | | | | | | |
| - Metered Sales (MC) | 7,654 | 8,477 | 11,031 | 9,890 | 9,991 | 10,388 | 11,536 | 10,112 | 10,914 | 10,612 |
| - Unmetered Sales (UMC) | 5,747 | 7,289 | 9,902 | 10,179 | 10,817 | 12,883 | 15,303 | 15,421 | 17,699 | 19,054 |
| **Total AG Sales (MU)** | **13,401** | **15,766** | **20,933** | **20,069** | **20,808** | **23,271** | **26,839** | **25,533** | **28,613** | **29,666** |
| **Average AG Consumption Index (kWh/HP/annum)** | | | | | | | | | | |
| - Metered AG Index (MC) | 1,025 | 1,079 | 1,160 | 1,061 | 1,068 | 1,183 | 1,308 | 1,308 | 1,307 | 1,308 |
| - Unmetered AG Index (UMC) | 1,274 | 1,317 | 1,417 | 1,140 | 1,180 | 1,242 | 1,383 | 1,383 | 1,448 | 1,383 |
| **Composite AG Index (derived)** | **1,154** | **1,195** | **1,282** | **1,099** | **1,119** | **1,209** | **1,339** | **1,243** | **1,357** | **1,354** |

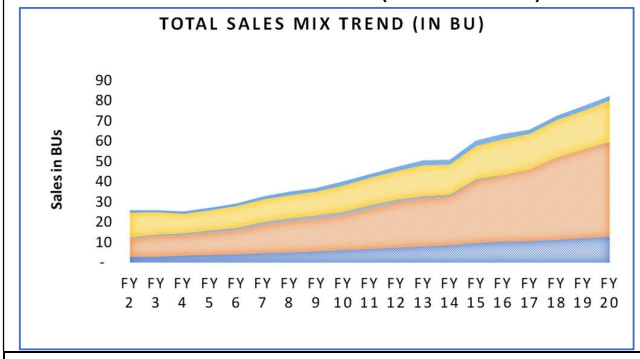
Source: MERC ARR/Tariff Orders for respective years

*Note: (figures for FY19 are as per projections under MTR Order (Case 195 of 2017). However, actual CL for FY19 as per MSEDCL MYT Petition is 214.92 Lakh HP)

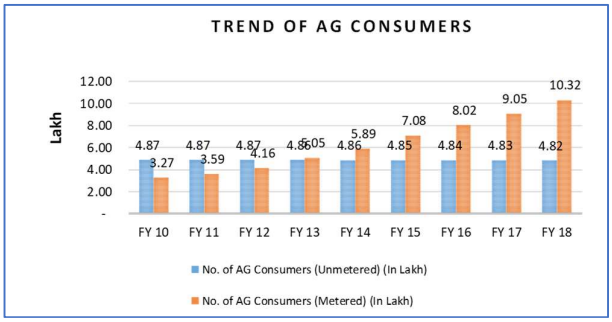
## 2. Gujarat

Agriculture sales constitute around 25% of the total sales of the Gujarat distribution utilities. Number of AG consumers have increased by over two times from 8.1 Lakh to 15.3 Lakh over past decade. Share of Metered to Un-metered Agriculture consumers constitute around 68:32. Total connected load of agriculture consumers in the system has almost doubled from 94 Lakh HP to 175 Lakh HP over the same period whereas reported AG sales has increased by only one and half times from 12.8 BU (FY10) to 18.3(est)(FY20). Historical trend of the number of consumers, connected load and sales of agriculture consumers is presented in the following graphs:

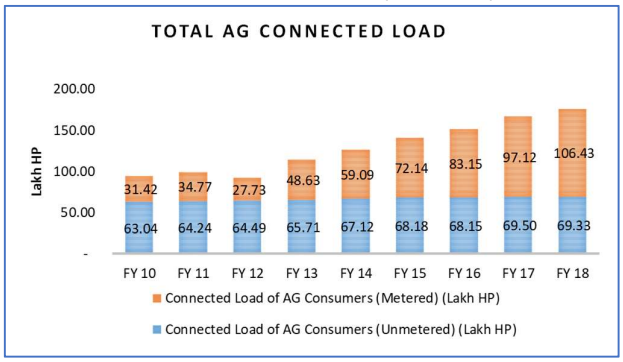
Historical Trend of total sales (Billion Units)



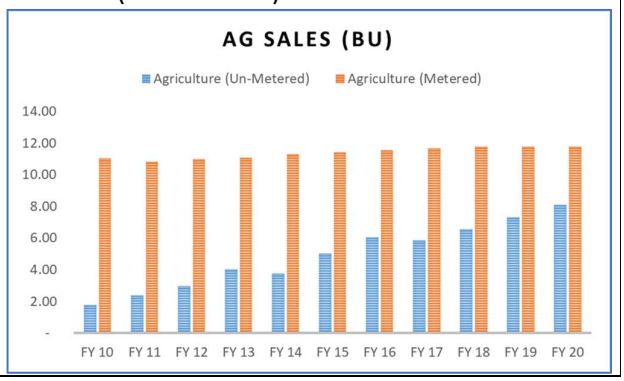

No. of AG Consumers (Lakh)




AG Consumer Connected Load (Lakh HP)




AG Sales (Billion Units)




(Source: GERC ARR/Tariff Orders for respective years)

Methodology adopted by Commission for verification and approval of the AG sales has remain same over the period. Assessment of Un-metered consumption is undertaken on the basis of AG Consumption norm study undertaken by Mishra Committee in 1999. The Commission has undertaken review of methodology in 2006 through another study but not adopted the same due to limitations of the study as per observations recorded in its Order. Subsequently, the Commission has continued with its earlier methodology for estimation of un-metered AG

consumption. Methodology for approval of AG Consumption as adopted by the Commission over the period is summarised below:

**(A) Applicable period: FY 1999-2000 to FY 2006-07**

*Reference Order: Case No. 19 of 1999 dated 10 October, 2000*

- The norms for AG consumption have been laid down by a **Committee constituted** by the Government of Gujarat called "**Mishra Committee Report**" dated **23 March, 1999**.
- This Committee was constituted to study the actual power consumption in the AG sector based on **4,000 odd meters** already installed on AG transformer centres.
- It was envisaged that the consumption data/pattern obtained from meters already installed could be utilized to explore and determine the extent of AG consumption.
- The Committee after making its study of the consumption pattern available on the installed transformers concluded that based on their estimate of AG consumption, **units consumed per year per kilowatt (kW)** of connected AG load ranged from **2,200 to 2,400 units**.
- For the purpose of estimating AG consumption, the Commission decided to adopt the same norms as laid down by the Mishra Committee.
- The norms laid down by the Mishra Committee, if adopted, at an average consumption of **2,300 kilowatt-hour (kWh)/kW** of connected load, will work out to **1,700 kWh/HP/annum**.
- The Commission adopted **the norm of 1,700 kWh/HP/annum** for the entire AG unmetered consumers.

**(B) Applicable period: FY 2007-08 to FY 2019-20**

*Reference Order: Case No. 899 of 2006 dated 31 March, 2007*

- GEB conducted AG study through an agency, complying to the directives of GERC in Order dated 10/10/2000. However, the Commission did not accept the same due to limitations of the study as per observations recorded in the Order.
- The Commission continued with estimation of the unmetered consumption as per the AG consumption norm **for un-metered consumers of 1,700 kWh/HP/annum**, earlier fixed by the Commission.
- For **metered consumers**, the AG consumption norm **in kWh/HP/annum** as computed based on the average consumption of the metered consumers for the past years to the average connected load in HP for the past years, i.e.,
    - C (in kWh) = (C1 + C2 + C3 + C4 + C5 + … + Cn)/n
    - L (in HP) = (L1 + L2 + L3 + L4 + L5 + ... + Ln)/n
    - AG Consumption Norm (Metered) = (C/L) kWh/HP/annum
      Where,
    - C = Average Consumption of AG Metered Consumers
    - L = Average Connected Load of the AG Metered Consumers
    - n = Years

**(C) Summary Statistics of AG Consumption (Gujarat):**

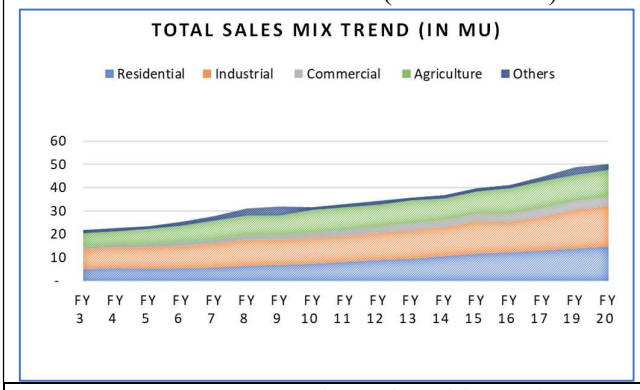
| Particulars | FY 10 | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 | FY 16 | FY 17 | FY 18 |
|---|---|---|---|---|---|---|---|---|---|
| **No. of Consumers (Lakh)** | | | | | | | | | |
| - Metered (MC) | 3.27 | 3.59 | 4.16 | 5.05 | 5.89 | 7.08 | 8.02 | 9.05 | 10.32 |
| - Unmetered (UMC) | 4.87 | 4.87 | 4.87 | 4.86 | 4.86 | 4.85 | 4.84 | 4.83 | 4.82 |
| **Total No. of AG Consumers** | **8.14** | **8.46** | **9.03** | **9.91** | **10.74** | **11.93** | **12.87** | **13.88** | **15.13** |
| **Connected Load (Lakh HP)** | | | | | | | | | |
| - Metered CL (MC) | 31.42 | 34.77 | 27.73 | 48.63 | 59.09 | 72.14 | 83.15 | 97.12 | 106.43 |
| - Unmetered CL (UMC) | 63.04 | 64.24 | 64.49 | 65.71 | 67.12 | 68.18 | 68.15 | 69.50 | 69.33 |
| **Total AG Connected Load** | **94.46** | **99.01** | **92.23** | **114.34** | **126.21** | **140.32** | **151.30** | **166.62** | **175.76** |
| **AG Sales (Million Units)** | | | | | | | | | |
| - Metered Sales (MC) | 11,043 | 10,841 | 10,974 | 11,070 | 11,311 | 11,429 | 11,548 | 11,659 | 11,775 |
| - Unmetered Sales (UMC) | 1,763 | 2,388 | 2,973 | 4,045 | 3,746 | 5,014 | 6,033 | 5,862 | 6,556 |
| **Total AG Sales (MU)** | **12,806** | **13,229** | **13,947** | **15,115** | **15,057** | **16,443** | **17,581** | **17,521** | **18,331** |
| **Average AG Consumption Index (kWh/HP/annum)** | | | | | | | | | |
| - Metered AG Index (MC) | 650 | 650 | 759 | 759 | 759 | 750 | 750 | 699 | 699 |
| - Unmetered AG Index (UMC) | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 | 1,700 |
| **Composite AG Index (derived)** | **1,356** | **1,336** | **1,512** | **1,322** | **1,193** | **1,172** | **1,162** | **1,052** | **1,043** |

Source: GERC ARR/Tariff Orders for respective years

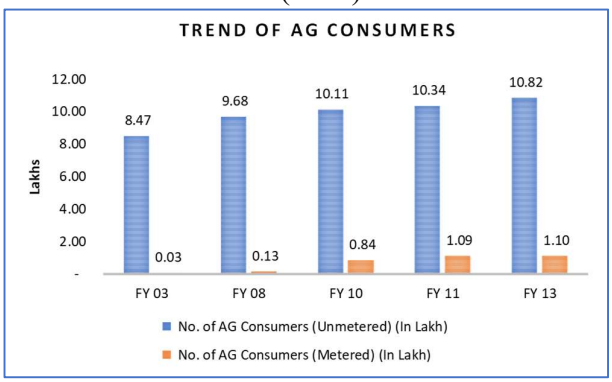
## 3. Punjab

Agriculture sales constitute around 25% of the total sales of the Punjab utility (PSPCL). Number of AG consumers have increased by 20% from 10.9 Lakh to 12.9 Lakh over past decade. Share of Metered to Un-metered Agriculture consumers constitute around 9:91. Total connected load of agriculture consumers in the system has increased by 33% from 96 Lakh HP to 128 Lakh HP over the same period whereas reported AG sales has increased by around 22% from 9.6 BU (FY10) to 11.8 BU (FY18). Historical trend of the number of consumers, connected load and sales of agriculture consumers is presented in the following graphs:

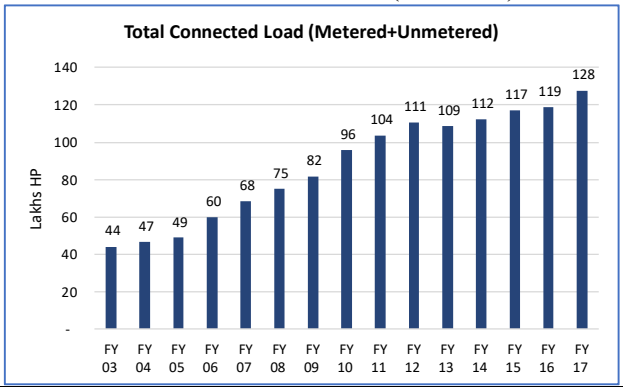
Historical Trend of total sales (Billion Units)



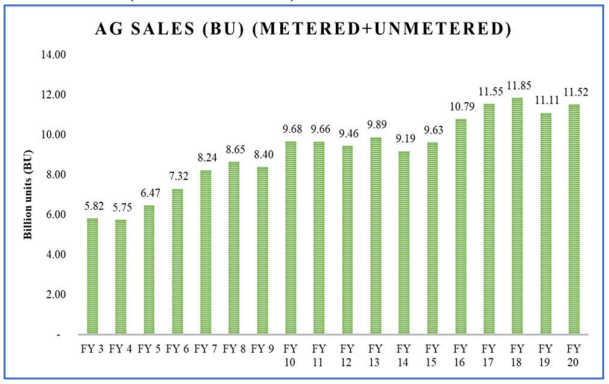

No. of AG Consumers (Lakh)




AG Consumer Connected Load (Lakh HP)*




AG Sales (Billion Units)




(Source: PSERC ARR/Tariff Orders and *Sigma Insights for figures for Connected Load (HP))

Methodology adopted by Commission for verification and approval of the AG sales has evolved over the period. Methodology for approval of AG Consumption as adopted by the Commission over the period is summarised below:

**(A) Applicable period: Prior to FY 2000-01**

*Reference Order: Case No. 3 of 2002 dated 6 September, 2002*

- Energy Consumption by AG Pumpset was derived using the formula as under:
  - AG Consumption = Energy Available (Generation + Purchase) – (Metered Consumption + pre-determined T&D losses)

**(B) Applicable period: FY 2001-02 to FY 2003-04**

*Reference Order: Case No. 12 of 2004 dated 30 November, 2004*

- PSERC has considered following studies while computing AG norm for FY 2002-03.
  - PSERC directed PSEB to conduct an assessment for estimating unmetered AG consumption in a state. Accordingly, PSEB has conducted study through Punjab Agricultural University (PAU).
  - PAU Study: The study provided **electricity consumption per hectare** for wheat, paddy, American cotton and other crops. (Electricity consumption is estimated based on the sample meters). The total electricity consumption for the above crops was arrived based on the area under each of the above crops for the respective years.
  - Commission also undertook comparison on Analysis of AG norm undertaken by Andhra Pradesh, Gujarat, Haryana, Maharashtra, Karnataka and Uttar Pradesh.
- World Bank through agency has conducted study for AG consumption in Haryana. The study covers the entire State and was based on sample metering and offers hours of pump usage per year. The same was also analysed by the Commission for similar cropping pattern and agro-climatic conditions being neighboring state.
- PSERC analysed the norms computed as per the above three studies and approved a norm as 1,700 kWh/kW per year for FY 2002-03.
- While truing up, it was observed that, due to partial failure of monsoon, consumption has increased. Hence, the Commission approved the agriculture consumption based on the norm by assuming 5% increase in connected load in the previous year.

**(C) Applicable period: FY 2004-05 to FY 2005-06**

*Reference Order: Case No. 4 of 2005 dated 14 June, 2005*

- AG sales are approved based on CAGR on previous year approved AG Sales

**(D) Applicable period: FY 2006-07 to FY 2008-09**

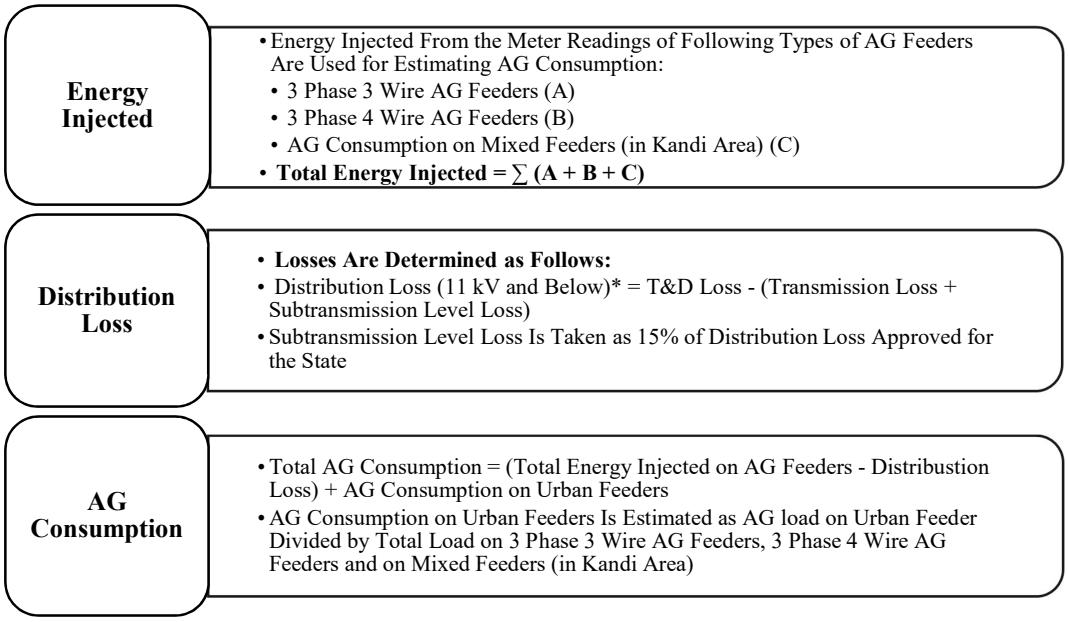
*Reference Order: Case No. 25 of 2009 dated 23 April, 2010*

- PSERC appointed agency for **comprehensive field study**. The Agency collected the details of connected load, supply hours and the consumption of sample meter connections from the Board's **System Losses Study Cell (SLSC)** in respect of all the **five circles**.
- Agency calculated the **month wise AP factor** of **each division** for all the **five circles** and thereafter computed the monthly consumption of each division by multiplying the AP factor thus arrived at with the total connected load of the division.

**(E) Applicable period: FY 2009-10 to till date**

*Reference Order: Case No. 71 of 2012 dated 10 April, 2013*

- From 2010-11 to present, PSERC is estimating AG consumption based on the **injected energy in feeders**.
- The Commission has approved AG sales in the previous tariff orders based on the CAGR and sample metering methodology. Further, the Commission observed various issues with the methodology entailing field study, hence the same was discontinued.
    - No uniform pattern was observed for the increase/decrease of AG consumption. Hence, it was inappropriate to estimate AG consumption based on CAGR.
    - Earlier, the methodology using sample meters was not reliable as it was observed during the months of April, May, November and December, 2012, that **more than 40% division of PSPCL had claimed AG consumption even more than the input energy**. Similar trends were observed from the scrutiny of the data for FY 2010-11 and FY 2011-12.
    - Accordingly, it was decided in the Tariff Order for FY 2013-14 to estimate AG consumption for review of FY 2012-13 on the basis of the **injected energy data** supplied by PSPCL. Loss is assumed in this method. PSERC has approved losses as per the trajectory set by the Commission to reduce T&D losses. The Commission has given directives to reduce T&D losses and accordingly trajectory and timelines have been given to PSPCL.
- Methodology followed for approval of AG sales from FY2010 onwards is as under:




**(F) Summary Statistics of AG Consumption (Punjab):**

| Particulars | FY 10 | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 | FY 16 | FY 17 | FY 18 |
|---|---|---|---|---|---|---|---|---|---|
| **No. of Consumers (Lakh)** | | | | | | | | | |
| - Metered (MC) | 0.84 | 1.09 | - | 1.10 | - | - | - | - | - |
| - Unmetered (UMC) | 10.11 | 10.34 | - | 10.82 | - | - | - | - | - |
| **Total No. of AG Consumers** | **10.95** | **11.43** | **11.63** | **11.91** | **12.25** | **12.36** | **12.61** | **12.87** | **-** |
| **Connected Load (Lakh HP)*** | | | | | | | | | |
| **Total AG Connected Load*** | **95.83** | **103.59** | **110.87** | **108.80** | **112.45** | **117.20** | **118.92** | **127.76** | **-** |

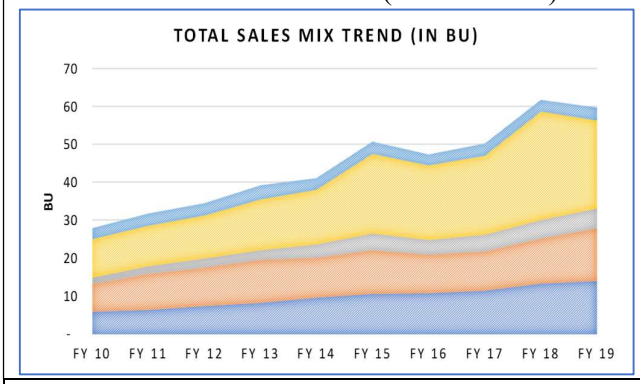
| Particulars | FY 10 | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 | FY 16 | FY 17 | FY 18 |
|---|---|---|---|---|---|---|---|---|---|
| AG Sales (Million Units) | | | | | | | | | |
| Total AG Sales (MU) | 9,678 | 9,656 | 9,455 | 9,886 | 9,191 | 9,630 | 10,794 | 11,546 | 11,850 |
| Average AG Consumption Index (kWh/HP/annum) | | | | | | | | | |
| Composite AG Index (derived) | 1,010 | 932 | 853 | 909 | 817 | 822 | 908 | 904 | - |

Source: PSERC ARR/Tariff Orders and *Sigma Insights for figures for Connected Load (HP)

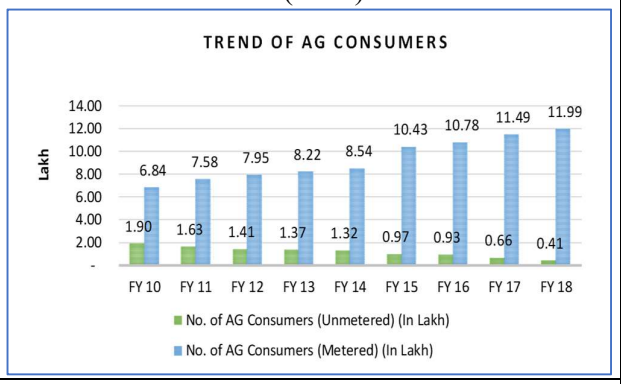
## 4. Rajasthan

Agriculture sales constitute over 38% of the total sales of the Rajasthan utilities (JVVNL, JdVNL, AVNL). Number of AG consumers have increased by 47% from 8.7 Lakh to 12.8 Lakh over past decade. Share of Metered to Un-metered Agriculture consumers constitute around 94:6. Total connected load of agriculture consumers in the system has more than doubled from 82 Lakh HP to 183 Lakh HP over the same period whereas reported AG sales has doubled from 10 BU (FY10) to 23 BU (FY19). Historical trend of the number of consumers, connected load and sales of agriculture consumers is presented in the following graphs:

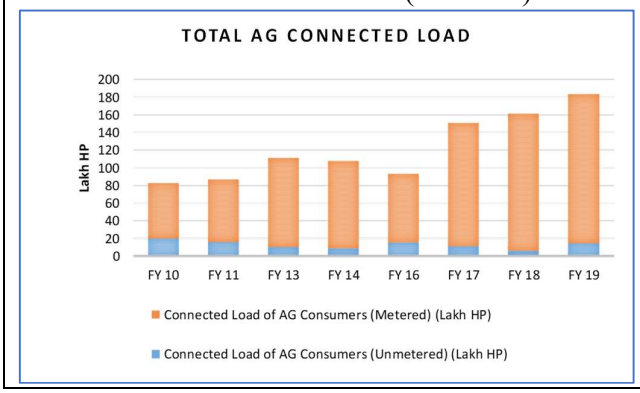
Historical Trend of total sales (Billion Units)



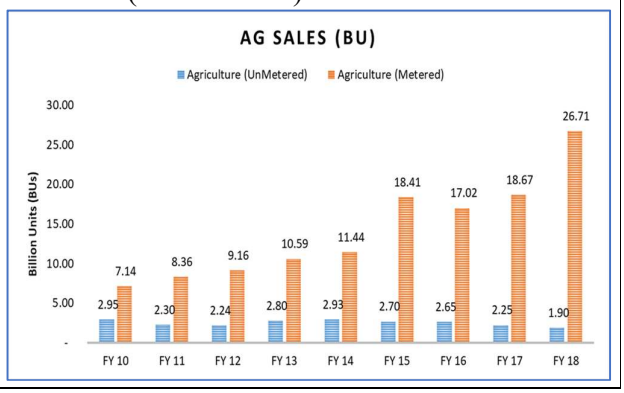

No. of AG Consumers (Lakh)




AG Consumer Connected Load (Lakh HP)




AG Sales (Billion Units)




(Source: RERC ARR/ Tariff Orders for respective years)

Methodology adopted by Commission for verification and approval of the AG sales has remained same over the period. Methodology for approval of AG Consumption as adopted by the Commission over the period is summarised below:

**(A) Applicable period: FY 2005-06 to till date**

*Reference Order: Case No. 1076/17 1077/17, 1078/17 dated 2 November, 2017*

- **For estimation of AG sales – Metered**
  - Step-1: Total connected Load = No. of Consumers * Average Connected Load

- No. of consumers considered: 100% existing AG Metered Consumers (full year), 50% of newly added Metered AG consumers (mid-year addition) and 50% Consumers converted from Flat Rate to Metered (mid-year conversion)
- Average Connected Load: (derived as 5.8 KW/consumer for metered for FY 2003-04)
- Step-2: Ag Sales per Annum = Total connected Load * AG Index (kWh/kW/year)
- For Existing & Newly Added Consumer's connected load – AG Index approved for Metered consumer category. (Index approved Y-o-Y)
- For Consumers converted from Flat Rate to Metered – Approved AG Index for Flat Rate Category for first year. **(1945 kWh/KW/month)**

- **For estimation of AG sales – Flat Rate (un-metered)**
  - Step-1: Total connected Load = No. of Consumers * Average Connected Load
  - No. of consumers considered: 100% existing AG Flat Rate consumers, Less, 100% Consumers converted from Flat Rate to Metered.
  - Step-2: Ag Sales per Annum = Total connected Load * AG Index (kWh/kW/year)
  - For Existing Flat Rate Consumers – Approved AG Index **(1945 kWh/KW/month)**

**(B) Summary Statistics of AG Consumption (Rajasthan):**

| Particulars | FY 10 | FY 11 | FY 12 | FY 13 | FY 14 | FY 15 | FY 16 | FY 17 | FY 18 | FY19 |
|---|---|---|---|---|---|---|---|---|---|---|
| **No. of Consumers (Lakh)** | | | | | | | | | | |
| - Metered (MC) | 6.84 | 7.58 | 7.95 | 8.22 | 8.54 | 10.43 | 10.78 | 11.49 | 11.99 | 12.10 |
| - Unmetered (UMC) | 1.90 | 1.63 | 1.41 | 1.37 | 1.32 | 0.97 | 0.93 | 0.66 | 0.41 | 0.73 |
| **Total No. of AG Consumers** | **8.74** | **9.21** | **9.36** | **9.58** | **9.86** | **11.39** | **11.71** | **12.15** | **12.40** | **12.83** |
| **Connected Load (Lakh HP)** | | | | | | | | | | |
| - Metered CL (MC) | 62.19 | 71.13 | 71.05 | 100.88 | 98.58 | 98.45 | 77.87 | 139.55 | 154.96 | 168.46 |
| - Unmetered CL (UMC) | 20.36 | 15.83 | 35.50 | 10.04 | 8.81 | 57.83 | 15.48 | 11.06 | 6.27 | 14.67 |
| **Total AG Connected Load** | **82.55** | **86.96** | **106.54** | **110.92** | **107.39** | **156.27** | **93.35** | **150.61** | **161.23** | **183.13** |
| **AG Sales (Million Units)** | | | | | | | | | | |
| - Metered Sales (MC) | 7,141 | 8,355 | 9,156 | 10,589 | 11,438 | 18,414 | 17,017 | 18,671 | 26,712 | 21,707 |
| - Unmetered Sales (UMC) | 2,954 | 2,298 | 2,243 | 2,803 | 2,925 | 2,698 | 2,647 | 2,248 | 1,899 | 1,542 |
| **Total AG Sales (MU)** | **10,095** | **10,653** | **11,399** | **13,392** | **14,363** | **21,112** | **19,664** | **20,919** | **28,611** | **23,249** |
| **Average AG Consumption Index (kWh/kW/annum)** | | | | | | | | | | |
| - Metered AG Index (MC)* | 1,600 | 1,624 | 1,714 | 1,737 | 1,818 | 2,126 | 1,916 | 1,840 | 1,840 | 1,781 |
| - Unmetered AG Index* (UMC) | 1,945 | 1,945 | 1,945 | 1,945 | 1,945 | 1,945 | 1,945 | 1,945 | 1,945 | 1,945 |
| Composite AG Index (derived) (kWh/HP/Annum) | **1,223** | **1,225** | **1,070** | **1,207** | **1,337** | **1,351** | **2,107** | **1,389** | **1,775** | **1,270** |

Source: RERC ARR/Tariff Orders for respective years (*Denomination of AG Index norm approved by RERC is kWh/kW/annum, which reported as such)

## 8.3. Annexure 3: Comments received on sampling and survey approach

Key observations and suggestions received on the proposed sampling methodology and additional suggestions on AG field survey/study are summarised in below:

- MSEDCL submitted comments on "Sampling Methodology to derive AG consumption" proposed by AGWG. It was highlighted that, sample size of feeders should be large enough and 100% consumers on selected sample feeders shall be surveyed to have correct estimation of the consumption. Input at EHV should be considered as an important parameter as the data pertaining to EHV input is sourced directly from MSETCL's network and hence, there is least manual intervention. Further, AG consumption should not be decided on normative basis as it depends on various factors such as, rainfall, ground water availability, cropping pattern etc. and these conditions vary in every season. Hence, procedure of calculating AG consumption should be continuous, not one-time exercise. As regards data to be collected from survey, it was submitted that, the parameters based on the consumer interview would be subjective and depend upon individual's assessment of the question which attracts individual's bias and thus cannot be relied upon. Therefore, such findings should be thoroughly cross verified based on the parameters derived from meter reading or any other such instrument in which the human intervention is minimal. It was also submitted that, a specific concrete methodology for assessing the agricultural consumption using the various gathered information shall be brought out clearly in the document.
- Prof. Priya Jadhav submitted that feeder level AMR data should be relied upon for getting Agricultural consumption, as it is the only reliable data. A straightforward exercise of collecting substation level feeder data can reliably support the Commission's aim to reach a fairly accurate figure. Current method of estimation using billing data will lead to unlikely results due to unreliability of billing data.
- Dr. Ajay Chandak suggested stepwise description of the methodology for sampling and estimation of AG consumption as under: (a) Divide all AG feeders in say 4 groups on the value of total annual consumption divided by connected load. Say groups A,B,C,D. (b) From every group randomly chose 20% feeders (c) For every chosen sample feeder: (Total annual consumption on feeder- non AG billing on that feeder) = AG consumption of that feeder (d) AG consumption of the feeder/connected AG load in H.P. leads to kWh per H.P. figure which should have been billed. (e) Average of billing figure in a group should be applicable to that group. (f) Repeat the process for all groups.

- Maharashtra Veej Grahak Sanghatana submitted that to estimate the agricultural consumption for the earlier years, it should be calculated on the basis of feeder input as below,
    - (A) For 100% agricultural feeders : Real Consumption = (Feeder Input Units - Normative losses)/ Agri. Connected Load on the feeder
    - (B) For Agri. dominated or mixed feeders: Real Consumption = (Feeder Input - R/C/I Sales - Normative losses)/ Agri. Connected Load on the feeder
- Further, consumption from FY 2014-15 to FY 2018-19 should be finalized on the basis of Feeder Input norms and the implementation should be done from FY 2014-15
- 100% verification or investigation of all AG consumers should be done by an independent & technical third-party agency by MERC & not by MSEDCL. Further, it suggested that Report by Working group should be published and implemented.
- Shri Ramesh Sundaresan suggested to add following queries in the questionnaire as under:
    - Whether the Motor is being used in the peak consumption time of 6 PM to 9.30 PM and if Yes, used for how many hours?
    - Average water table level in the farm (from the surface )- ( Since the amount of power consumption is associated with the water table level)

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## 8.4.Annexure 4: Technical loss estimation methodology

The calculation of technical loss on feeders is a vital step in estimating agriculture sales. In absence of dedicated exercise by the MSEDCL to estimate technical loss on the AG feeder network, the working group was constrained to undertake indicative estimation of technical loss on AG feeders. Given the scarcity of consistent metering data at the consumer level, it was not possible to estimate feeder and LT network losses based on the metering. Hence the WG has resorted to estimating AG feeder network losses based on engineering methodology, that is, $I^2R$ loss computation. This annexure explains the methodology adopted by the WG for such estimation.

Technical losses in the network vary significantly as per feeder loading conditions. To account for this, five different feeder loading conditions as below are considered.

1 Excess load – Feeder load more than the total connected load on the feeder,

2 Peak - Feeder load between 75% and 100% of the total connected load

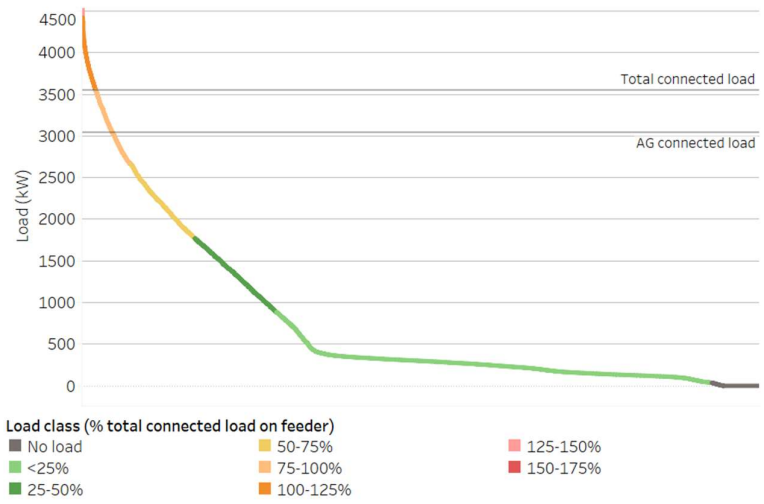
3 Intermediate - Feeder load between 50% and 75% of the total connected load,

4 Low - Feeder load between 25% and 50% of the total connected load

5 Very low - Feeder load less than 25% of the total connected load

For each of these loading conditions/class, average feeder current and the duration (Hours) are calculated based on 30-minute slot-wise feeder load profile data through AMR / MRI meters. These two parameters form the basis for the calculation of losses on a feeder.

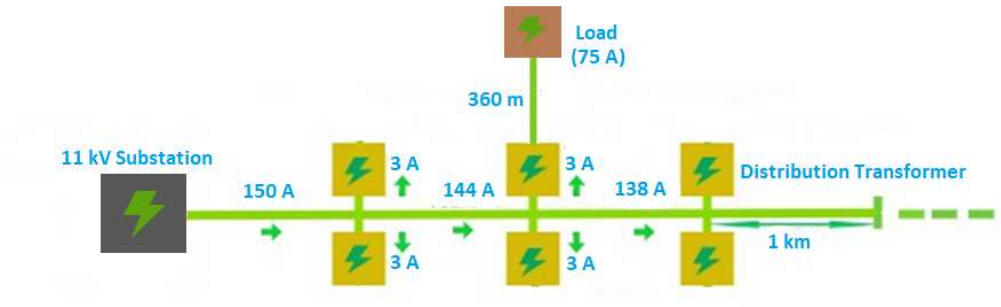
Pictorial depiction of the Load Duration Curve of the Feeder with moderate excess load condition is presented below as representative case:




For the purpose of analysis, a feeder network has been divided into three elements: 1. Feeder line 2. Distribution transformers 3. Low voltage (440 V) circuit. Annual technical losses are arrived at after adding losses in each of these three elements for all loading classes i.e. from excess load to very-low load condition.

The feeder line is assumed to be radial have 'n' number of equally spaced nodes, each having two distribution transformers (DTs) connected in parallel. This arrangement forms 'n' sections on the feeder, each section having reducing values of line currents as we move along the feeder**.** Losses in each section are summed up to get the annual losses on the feeder line. For example, for a 25 km long feeder with 50 DTs, and substation end current of 150 A, each segment will be of 1 km and current will reduce by 6 A for each segment.

**Schematic of feeder segmentation considered for loss calculation**



All the DTs are assumed to be equally loaded and receive the same input at the H.T. side, which equals feeder input less annual feeder losses divided by total number of DTs. Losses in DTs are worked out after taking into account the DT efficiency of 98%.

Low voltage network is simplified by treating all load lumped at a certain distance from the DT, and the current flowing in the network can be obtained by converting H.T. side current using transformation ratio (Ratio of rated HT voltage to rated LT voltage).

For calculation of losses, resistivity values have been taken from relevant IS standards, while the details of feeder length and conductor size have been provided by the MSEDCL. LV circuit length is considered to be 360 meters based on the survey responses.

In the end, losses in all three elements are added up and expressed as % of annual feeder input. To account for field conditions such as joint losses, conductor aging, reduction in DT efficiency, effects of low voltage conditions, unbalanced loads, etc. 3% point additional losses are considered.

## 8.5.Annexure 4: Comments and Suggestions on AG Study Interim Report

AG Study interim report, dt. 22 January 2020 was published on MERC Website for public consultation. Based on the interim report, various stakeholders and other individuals submitted their comments and suggestions. Working Group has considered all the suggestions and objections while finalizing the report.

List of Individuals / organisations who submitted comments and suggestions on Interim report and gist of their comments is presented below.

Shri. Pratap Hogade of Maharashtra Veej Grahak Sanghatana has given suggestions and objections on AG consumption estimation methodology of MSEDCL and billing mechanism. Referring to its submissions and records filed as part of Case No. 63 of 2013, proceedings, it was suggested to recheck and take into consideration actual technical loss and AG consumption as per records. Further, as MSEBHCL conducted a similar study through IIT- Bombay and although there is difference between the opinion of recommendations by committee members, IIT-B report is final and hence MERC should consider the same before finalizing the report of AG working Group. IIT-B estimated AG Index as **1063 hrs / yr.** (15,574/- MU) for FY 15-16 in that study report which is lesser than the index estimated by Working Group.

Members of Maharashtra Veej Grahak Sanghatana have analysed the data on region-wise consumption of AG consumers in State and it is observed that, annual hours of operation for lift irrigation schemes, which get 16 hrs. / day supply and mostly irrigate sugarcane, are **1875 hrs./ yr.** Considering that LT pumps receive supply for much less hrs./ day and operate for less no. of days, maximum operating hrs for LT pumps would be **1055 hrs./ yr.** as against **1425 hrs./ yr.** as per Interim report. So, it can be said that, actual AG consumption is less than AG consumption estimated in Interim Report. In addition to it, Sanghatana has filed RTIs in December 2011 and March 2012 from which it is observed that, there is excessive increase in connected load of AG unmetered consumers without consumer demand or assessment. Under bill correction campaign, AG bill arrears of 3281 AG consumers were reduced by 48%, implying that AG bills are inflated by 100%. Hence, accurate estimation of connected load of AG consumers and mapping of consumers is required to be done. Based on above all analysis and observations, following recommendation were given:

a) As per MERC orders, undertake final true-up of past years based on revised AG sales, provided estimates of impact of revised AG sales on overall tariff, AG arrears and government subsidy.
b) MSEDCL should be directed to re-submit ARR petition considering significant impact of AG sales and revision thereof.
c) Adopt feeder input and feeder connected load-based AG billing system.

d) Ensure correct consumer mapping and connected load.
e) Based on water requirement of Sugar cane, even for sugarcane maximum hours of pump operation would be **1150 Hrs./ HP / Yr.**

MSEDCL submitted its comments/suggestions on 16-Jan-2020 on the preliminary analysis as presented during Working Group meeting held on 2-Jan-2020 as well as on the Interim Report which was published for public consultation. Comments submitted by MSEDCL before publication of interim report were published on MERC website along with the Interim Report. MSEDCL submitted that, Technical Loss assessment considered by WG (which is in the range of 16-20%) is too high. Actual technical loss on AG feeders is around 8% as per the methodology of MSEDCL to estimate technical loss. MSEDCL estimated technical loss as per the formula below:

Technical Loss of feeder = HT Line Loss+ DTC Loss + LT Line Loss+3%

From detail calculation of **37 feeders**, the **Technical Loss** is in the range of **1.55% to 5.02 %**. With **addition of 3% losses accounted** for deteriorated lines due to aging, joints on HT/LT lines, repaired DTCs and non-ideal field conditions, the technical loss of feeder can be **considered as 8%**.

Filtering criteria for feeder selection of AG consumption norm set by WG (lower range of 300 hours and upper range of 3000 hours) is not appropriate. Considering 8% technical loss and no cut-off (filtering criteria), the AG consumption norm for 498 feeders, if applied on 215 Lakh HP leads to total AG consumption of 33,565 MU. Considering 8% technical loss and no cut-off (filtering criteria), the AG consumption norm for 325 feeders, if applied on 215 Lakh HP leads to total AG consumption of 29,162 MU. Further, Energy Consumption and Feeder input (AMR/MRI) of 185 feeders as per assessment due to technical reasons not considered. Feeder data of Connected load and Non-AG sale of corrected mapping as per the data file shared on 21 November, 2019 instead of 24 October, 2019 to be used.

MSEDCL also pointed out that the feeder data inputs considered for analysis should be based on file shared on 21.11.2019 instead of data file shared on 24.10.2019. In this context, MSEDCL made specific observations/suggestions were as under:

1. **Connected Load & Non Ag sale**: Connected load of the feeder should be considered as per data submitted on 21.11.2019 in which mapping was corrected.
2. **Energy Consumption on Feeder Meter**: The feeder inputs calculated on the basis of AMR/MRI reading of 01.04.2018 & 31.03.2019. But the assessment given on 185 feeders due to technical reasons in not considered. The data submitted to Hon'ble MERC vide dt. 21.11.2019 covers energy consumption by feeder meter reading and assessment provided.

MSEDCL has also submitted that presumption of Non-AG sale is being booked in AG sale is not correct considering the losses of Non-Ag circles, losses of Towns of AG dominated Circles, also by correlating with EHV feeder input of AG dominated feeders.

Advt. Anil Chavan from Nashik stated that, individual AG consumer metering is necessary, and Commission should provide budget for the same, Sample based assessment as per IR should be taken as guideline.

Shri. Brijmohan Mishra pointed out the implications of AG restatement and emphasised upon further action thereon.

Mr. Ulhas Chaudhari stated that, hydro and RE generation should be reserved for AG consumption, including agro-industries, drip irrigation should be made mandatory for AG connection, use of solar pumps should be promoted, competitive bidding for solar pumps and drip shall be adopted.

IWPA stated that, due to excessive AG consumption estimated per year by MSEDCL in past years, higher CSS has been levied on other consumer categories. Hence, it requested Commission to reconsider CSS computation of past years.

Irrigation Federations of Kolhapur region stated that, MSEDCL shall use feeder input and feeder connected load for AG billing and AG consumption estimation in future years. Further, it is suggested to implement recommendations given by Working Group in Interim Report.

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