BASELINE KPI REPORT

Prepared by –

PFC CONSULTING LTD.

Sub consultants

FEEDBACK INFRA
Making Infrastructure Happen

Submitted to -

OPTCL
Lifeline of Odisha

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Verification certificate

CERTIFICATE ISSUED BY CERTIFIED ENERGY AUDITOR

This is to certify that M/s Feedback Infra Private Limited has completed the third-party independent verification of AT&C losses at Rourkela smart city project area for the period FY 17-18 and FY 18-19 (till December). Results of the verification are as follows:-

Parameter	UoM	FY 2017-18	FY 2018-19
Input Energy	LU	3,199.09	2,964.18
Billed Energy	LU	2,320.12	2,396.70
Billed Amount	INR Lacs	12,109.35	13,304.66
Collected Amount	INR Lacs	11,610.67	12,439.40
Billing Efficiency	%	72.52%	80.86 %
Collection Efficiency	%	95.88 %	93.50 %
AT&C loss	%	30.46%	24.40 %

The methodology and results have been verified by undersigned certified energy auditor.

Certified by –

Shailesh Jagannath Kalrao
(Vice President)
Feedback Energy Distribution Company (FEDCO)
Certified Energy Auditor

Executive Summary

Rourkela circle consists of three main divisions from which 11 kV feeders are currently catering to the smart city area under Rourkela Municipal Corporation (RMC). These divisions are – Rourkela Electrical Division (RED), Rourkela Sadar Electrical Division (RSED) and Rajgangpur Electrical Division (RJP). RJP provides only 2 nos. 11 kV feeders catering to Rourkela Smart city area.

This report outlines the process and verification results for baseline parameters such as AT&C loss, technical loss, transformer failure, system reliability and power quality. Data for the study has been collected for the period FY 2017-18 and FY 2018-19 from MRT division and commercial sections of all three divisions of Rourkela circle. Summary of findings regarding AT&C loss study are as follows:

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Collected Amount	INR Lacs	11,610.67	12,439.40
Billing Efficiency	%	72.52%	80.86 %
Collection Efficiency	%	95.88 %	93.50 %
AT&C loss	%	30.46%	24.40 %

Technical loss at 33 kV system is 2.45% and technical loss at 11 kV system (sample feeders) is 7.49%. Voltage at 33 kV and 11 kV level is within permissible limits whereas power factor and harmonics are also within permissible limits. Transformer failure stands at 2.06% only (excluding HDVS transformers)

Background of the study

Need of Smart Grid leading to Smart City

1. Energy needs of the country are growing at a very rapid pace. In order to meet increasing energy demand, amidst growing environmental concerns as well as energy security issues, we need to increase efficiency in all value chain viz. generation, transmission & distribution. More importantly, efficiency needs to be increased to a point where we shall actually be using less energy to power more establishment/ businesses.

2. Further, to be sustainable, we must be able to produce the amount of energy we need, without much impact on environment through renewable and other non- conventional resources. Consumer aspiration on quality supply, as well as operation in open electricity market regime, integration of renewable energy sources which are intermittent and variable in nature, are also posing new challenges which needs to be addressed. Smart Grid offers a solution towards above challenges. Smart Grid is a confluence of Information, Communication, Electrical/ Digital technologies, integrating all users to efficiently balance demand and supply over an increasing complex network.

3. Cities occupy 4% or less of the world's terrestrial surface, yet they are home to almost half the global population, consume close to three-quarters of the world's natural resources, and generate three-quarters of its pollution and wastes. The United Nations estimates that virtually all net global population and economic growth over the next 30 years will occur in cities, leading to a doubling of current populations. India is also not untouched with above phenomenon. Our cities are becoming more populated continuously as people are migrating from rural areas towards urban areas for more facilities, better life, education and employment.

4. India is urbanizing at an unprecedented rate so much that estimates suggest nearly 600 million Indians will be living in cities by 2030, up from 290 million as reported in the 2001 census. Increasing urban population and unprecedented load on aged and insufficient infrastructure in our cities has forced many challenges for fulfilling basic facilities like home, energy, employment, health, mobility etc. In addition, infrastructure to supply commodities like electricity, water, gas is becoming insufficient to cater such an inflow of population. Improved living standard of people is resulting in higher consumer aspirations and affordability.

5. Therefore, there is a need for development of Smart Grid leading to smart cities, to provide quality life for its citizens for inclusive growth, generate employment as well as reduce pressure of infrastructure requirement on other large cities. Strengths of Smart Grid technologies can transform cities to smart cities which shall facilitate in increasing human productivity, realization of inherent urban potential and lesser use of natural resources per person, information access & processing to improve citizen services etc.

Smart Grid Implementation will bring the following advantages:

a) Accurate and well-timed Meter Reading;
b) Commercial Loss Reduction;
c) Remote connection disconnection of consumer load;
d) Accurate tamper alert;
e) Notification of sanctioned load violation at consumer level as well as DT overloading;
f) Effective Outage Management System linked with Sub Station SCADA and Ring Fencing to minimize losses during outage;
g) Time-based pricing (Time-of-Use Tariff); and
h) Peak Load Management to maximize available energy

Objectives of the Smart Grid Project

Following objectives have been outlined for development of Smart Grid in Rourkela Smart City

1. Reduction of AT&C Loss.
2. Automate Grid Operations and perform an accurate DT wise Energy Audit.
3. Increase in billed energy.
4. Empowerment of consumers to participate in the energy management.
5. Improvement in reliability by reduction in outage rate and duration.
6. Improved administration decision making through GIS tools.
7. Increase in customer satisfaction and consumer awareness.
8. Proposed Smart Grid technologies, would facilitate efficient, accurate & effective online recording & monitoring of the energy exchanges in distribution system to reduce AT&C losses and operational errors viz. reading error, bias error, typographical errors etc. caused by involvement of human element.
9. Implementing technologies that would enhance quality of power at doorstep of consumers and would help in proper monitoring of assets for extended life.
10. Efficient system operation by better load management.
11. Enable high level of customer satisfaction and increased awareness.
12. Demand Side Management to ensure maximization of available power

Rourkela Smart Grid Leading to Smart City

Rourkela is one of Odisha's five major cities and is one of the largest urban centers located in Chota Nagpur Plateau is an important industrialized city of the region. The region has a rich and long history of indigenous settlement (Tribes like Oraons, Mundas, Kharias, Bhuiyans and Bhumijs). It is also one of the two proposed smart cities from the State of Odisha; selected by the GoI and is the Steel City of Odisha. It has an area of 53.29 km² and its demography provides a Railway gateway for access to Eastern Part of India to Southern Part of India and Western Part of India. The population of Rourkela is over 3.09 lakhs and power consumers are over 81,000 nos. Consumers in Rourkela get electricity from Western Electricity Supply Company of Odisha (WESCO), one of the distribution utilities catering to Western part of Odisha with headquarters at Burla.

WESCO is the power distribution utility distributing electricity to the consumers of western part of Odisha covering 9 revenue districts namely Sambalpur, Bargarh, Jharsuda, Deogarh, Sundargarh, Subarnapur, Bolangir, Kalahandi and Nuapada etc. For smooth functioning of utility, activities is divided into 5 circles comprising different revenue districts.

a) Sundargarh District- Rourkela Circle

b) Jharsuguda & Sambalpur District- Sambalpur Circle
c) Bargarh District- Bargarh Circle
d) Subarnapur & Bolangir District- Bolangir Circle
e) Kalahandi & Nuapada District- Kalahandi Circle

Rourkela is divided into mainly 2 urban centers – Rourkela Municipal Corporation (RMC) with an area of 53.3 Sq Kms and the Rourkela Steel Township (RST) with an area of approximately 54 Sq Kms. As per census of 2011, the population of RMC and RST is around 3.09 Lacs and 2.1 Lacs respectively. The current proposal is for development of Smart Grid in RMC area. Known as the Steel City, with the presence of SAIL's first Integrated Steel Plant; Rourkela Industrial Area further has 43 Sponge Iron Plants, 3 cement industries and around 350 MSMEs'. However for implementation of Smart Grid, the following have been excluded:

a) Area of Rourkela Steel Plant and its residential areas
b) Area of Railway and its residential colony
c) Area of National Institute of Technology (NIT) and, its residential colony

Odisha Power Transmission Corporation Ltd (OPTCL) and WESCO have appointed PFC Consulting Ltd (PFCCL) for undertaking various activities for development and implementation of smart grid in Rourkela city.

PFCCL has engaged Feedback Infra Pvt. Ltd. for study and evaluation of baseline KPIs for implementation of Smart Grid in Rourkela. The baseline KPIs covered under the project are as follows –

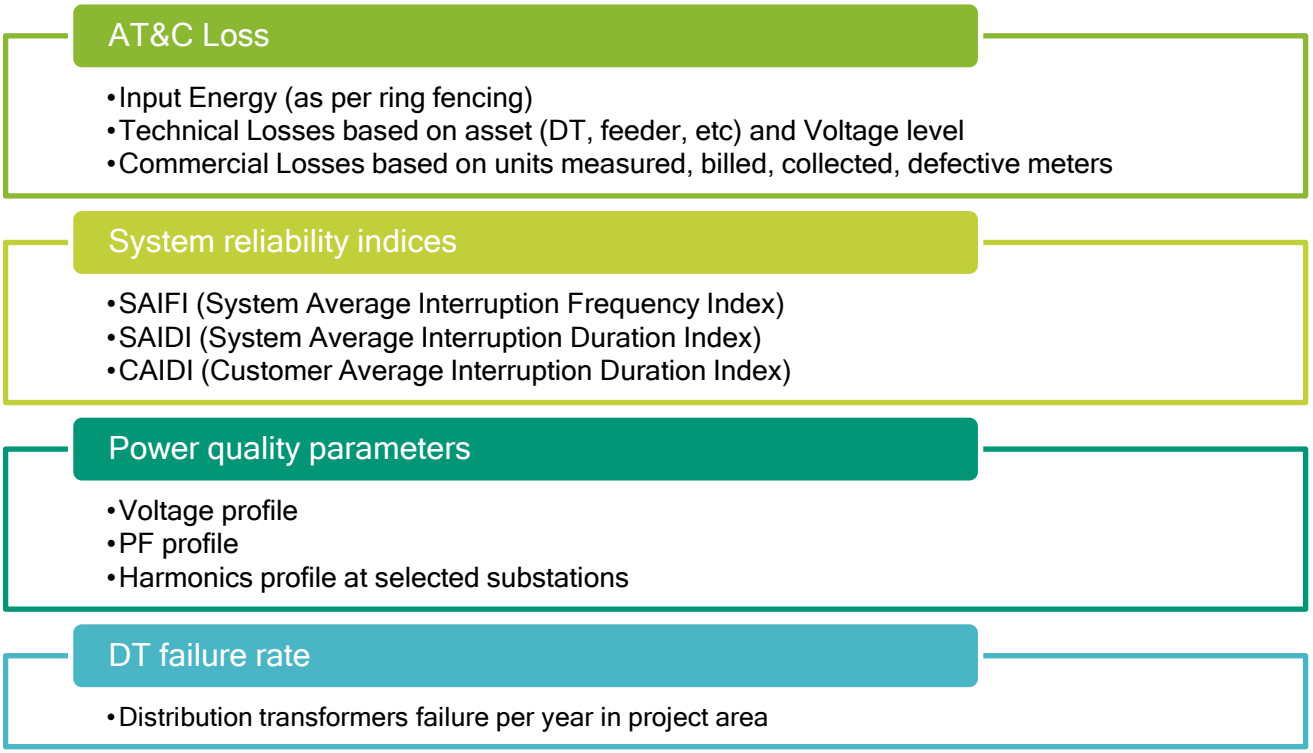


Figure 1 - List of Baseline KPIs covered under the project

Salient features of the distribution network of the smart city area are as follows –

Sl. No	Particulars	UoM	Value
1	Area covered under smart city	Sq. km.	53.29
2	No. of division offices	Nos.	3
3	No. of sub-division offices	Nos.	7
4	Population covered (as per 2011 census)	Nos.	3.09 Lakhs
5	Total consumers (approx.)	Nos.	86,768
6	No. of 33 kV feeders (Full & Partially feeding)	Nos.	10
7	No. of 11 kV feeders	Nos.	42
8	Length of 33 kV lines	Ckt km.	79.01
9	Length of 11 kV lines	Ckt km.	236.23
10	Length of LT lines	Ckt km.	377.81
11	No. of 33 / 11 kV substations	Nos.	18
12	No. of 33 / 11 kV power transformers	Nos.	38
13	Capacity of 33 / 11 kV power transformers	MVA	250.85
14	No. of 33 / 0.4 kV distribution transformers	Nos.	13
15	Capacity of 33 / 0.4 kV distribution transformers	MVA	1.7
16	No. of 11 / 0.4 kV distribution transformers	Nos.	1194
17	Capacity of 11 / 0.4 kV distribution transformers	MVA	167.36

Table 1 - Salient features of the distribution network of the smart city area

Category-wise consumer details under smart city area are as follows –

Sl. No.	Category of consumers	RED	RSED	RJP	Total
1	Domestic	43,676	27,179	3,411	74,266
2	Commercial	7,892	3,200	811	11,903
3	PHD	19	19	3	41
4	Street Light	8	1	6	15
5	Small Industry	147	93	83	323
6	Medium Industry	19	75	65	159
7	HT Industry	23	29	9	61
Total		**51,784**	**30,596**	**4,388**	**86,768**

Table 2 - Category-wise consumer details under smart city area

Concept of AT&C losses

AT&C losses provide a realistic picture of energy & revenue loss situation. These losses comprise of two elements-

1. **Technical loss** - The technical losses primarily take place due to the following factors:-

a) Transformation Losses (at various transformation levels)

High I^2R losses on distribution lines due to inherent resistance and poor power factor in the electrical network. The level of technical losses varies with type of conductors used, transformation capacity of transformers and reactive loads among other factors. There are number of software available in market through which losses can be computed. The essential requirements for calculating technical loss on power distribution network of any project areas are –

a) 33 kV and below HT network Line Diagrams
b) Line Diagrams for each of distribution transformers and LT circuits up to poles/feeder pillars
c) Voltage levels, Power factor and Current loading on HT/LT network & network equipment
d) Line lengths, cross section & nature of material, network equipment's load curve etc.

2. **Commercial loss -** Any illegal consumption of electrical energy, which is not correctly metered, billed and revenue collected, causes commercial losses to the utilities. The commercial losses are primarily attributable to discrepancies in –

    a. **Meter reading** - Commercial losses occur due to discrepancy in meter reading. Meter reading problems are manifested in form of zero consumption in meter reading books which may be due to premises found locked, untraceable consumers, stopped/defective meters, temporarily disconnected consumers continuing in billing solution etc.

    Further, coffee shop reading, collusion with consumers is also source of commercial losses to utilities which are primarily due to suppressed meter reading.

    b. **Metering** - Most of utilities across India are using either electro-mechanical or electronic meters for consumer metering. Commercial losses through metering can be in form of meter tampering in various forms, bypassing of meters, usage of magnets to slow down the meters, tampering of PT circuits, CT/PT ratios (in case of HT meters) etc.

    c. **Theft by direct hooking** - This is most common and visible form of commercial losses in which people tend to tap LT lines to indulge in theft through direct hooking.

    d. **Collection efficiency** - Typically in a billing cycle, a distribution utility issues bills against metered energy and assessed (generally in case of agricultural loads and temporary connections) energy. However, in most of instances utility is not able to collect the complete amount billed by it. The ratio of amount collected to total amount billed is termed as collection efficiency. Needless to say that low collection efficiency implies higher commercial losses.

The revenue collected shall exclude the arrears .However in case figures of arrears not available separately; there is possibility to getting collection efficiency figures of more than 100%. In such cases

efficiency shall be restricted to 100% and shall be used for computation of AT&C losses. The amount attributing collection efficiency higher than 100% shall be treated as collection against arrears.

Methodology of verification

PFC has issued a guideline in September 2009 with regard to methodology for establishing baseline AT&C losses. This methodology underlines the procedure for establishing baseline losses for a project area. Although PFC prescribes the verification of AT&C loss by taking data for 3 billing cycles. The same was reiterated in given scope of work. However, upon consultation, it was suggested that data for FY 2017-18 and FY 2018-19 (Q1 to Q3) shall be collated and analyzed in order to account for seasonal variations.

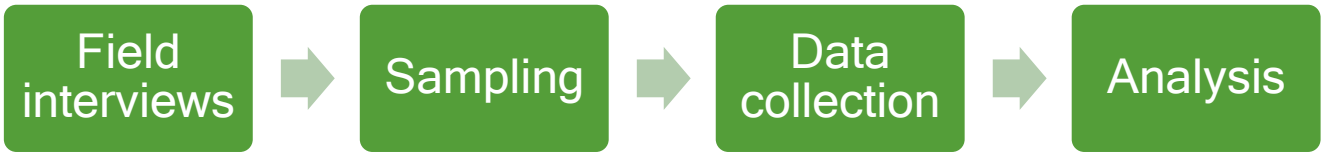


Figure 2 - Methodology for verification

Field interviews

Information regarding network – such as Single Line Diagrams (SLDs), input energy sheets, billing database etc. has been collected from the office of Superintending Engineer and all three division offices which are covered under the area of Smart city project. Interviews conducted during field visit are as follows:

Sl. No.	Officer Name	Designation	Circle / Division	Data / Information
1	Mr. A. N. Meher	SE (Rourkela)	Rourkela	Overview of operations, network etc.
2	Mr. J. C. Patra	EE (RED)	RED	Network details of feeders in RED division
3	Mr. B.K. Singh	EE (RSED)	RSED	Network details of feeders in RSED
4	Mr. P.K. Sahoo	EE (RJP)	RJP	Network details of feeders in RJP division
5	Mr. P. K. Sahu	DFM	RED	LT Billing database of RED division
6	Mr. Biswajit Dash	DFM	RSED	LT Billing database of RSED division
7	Mr. J. P. Lenka	DFM	RJP	LT Billing database of RJP division
8	Mr. Arvind Sahu	EE	MRT	TTB / Metering of 11 kV feeders
9	Mrs. Anamika	AE	MRT	Input energy, HT billing data

Table 3 - List of officials visited

Methodology of sampling

Wherever possible, 100 % samples have been taken. However, due to lack of appropriate data and paucity of time, certain samples have been taken for the dipstick study as mutually agreed with WESCO / OPTCL. Methodology used for sampling is given as follows –

KPI / Parameter	Sample methodology
AT&C loss	100 % feeders covering 33 kV and 11 kV level
Technical loss of 33 kV lines	100% 33 kV feeders
Technical loss of 11 kV lines	8 Nos. of 11 kV feeders as mutually agreed
T&D loss of LT network	10 Nos. of DTs as mutually agreed
SAIFI, SAIDI, CAIDI	100% 11 kV feeders with available data
Voltage & PF Profile	100% 11 kV feeders with available data
Total Harmonic Distortion	100% 11 kV feeders with testing facility
Transformer Failure	100% transformer failure covering all non-HVDS transformers
Consumer meter reading and billing	500 consumers covering all categories and feeders

Table 4 - Methodology used for sampling

Ring fencing & input points

According to PFC methodology for calculation of AT&C losses, "… utility can do ring fencing of towns through installation of import/export meters at project area boundaries. There can be 11 kV feeders feeding within and outside project area. The utility may install import/export meters at town boundaries and account for total energy supplied beyond town boundaries through them. While computing energy consumption of town, this energy may be subtracted from total energy consumption arrived from meter reading." Therefore, the electrical network of Rourkela has been studied in order to determine import and export points for Smart City area.

The entire city can be divided into three main zones namely –

a. Rourkela Municipal Corporation area (RMC area)
b. Rourkela Steel Plant Area (RSP area)
c. NIT Area

Out of these three areas, RMC area shall only be covered under the Smart city project. Therefore, feeders at 33 kV and 11 kV level providing power within RMC area have been evaluated for the purpose of Baseline study. Methodology of determining the ring fencing is discussed in the following section.

Determination of ring fencing

There are 2 nos. of 132 / 33 kV Grid Sub-Stations (GSS) feeding electricity to Rourkela Smart City project area (RMC area as specified above). There are 10 nos. of 33 kV feeders emanating from these 132 / 33 kV GSS which partially or fully provide power within the Smart city area. Out of these, 6 nos. of 33kV feeders are fully catering to smart city area, whereas 4 nos. partially cater to smart city area.

It may be noted that 33 kV and 11 kV network has undergone changes from FY 17-18 to FY 18-19. Current network configuration of FY 18-19 is given as follows –

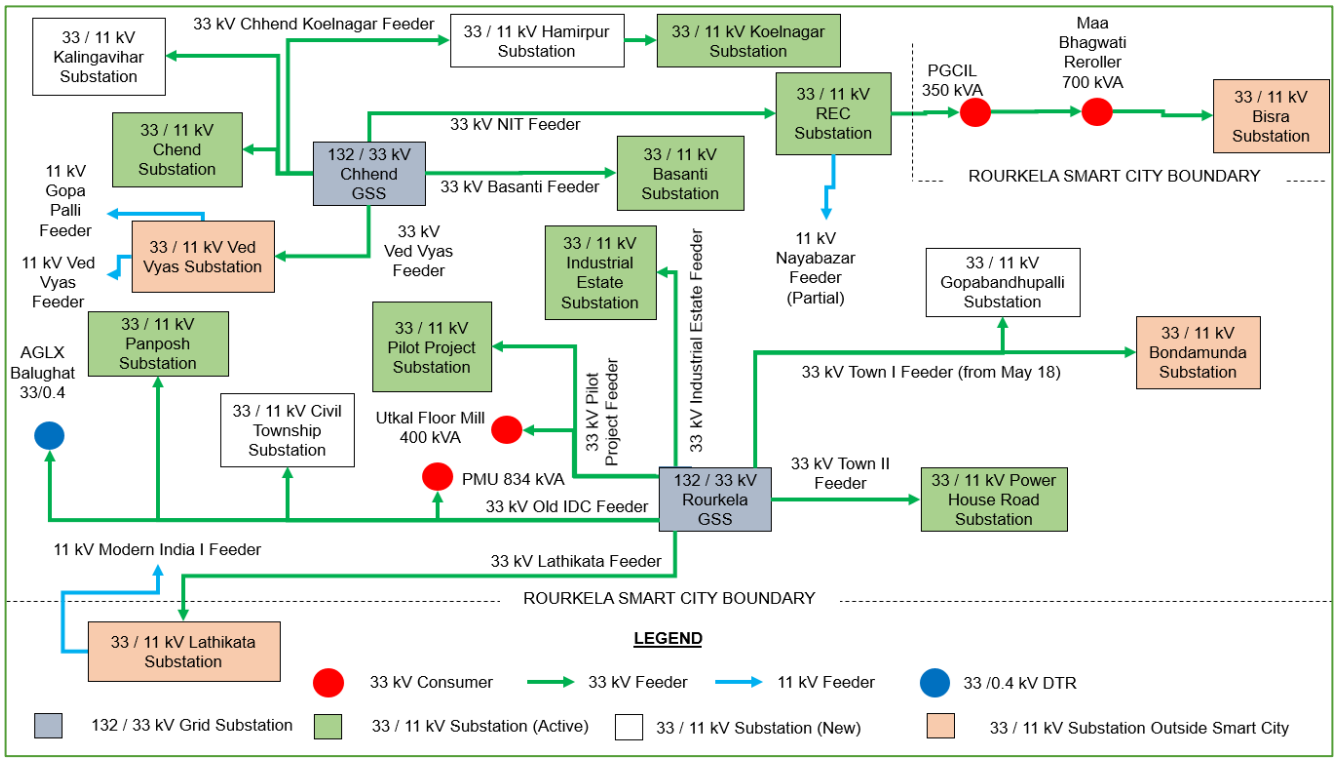


Figure 3 - 33 kV network configuration for FY 18-19

Key maps of Rourkela Smart city

Key map of the electrical network of Rourkela Smart city area has been provided by WESCO. This map shows the location of 132 / 33 kV GSS, 33 / 11 kV substations as well as interconnecting 33 kV lines. The key map may be broken down into 5 parts for easy reference. The maps are enclosed for reference –

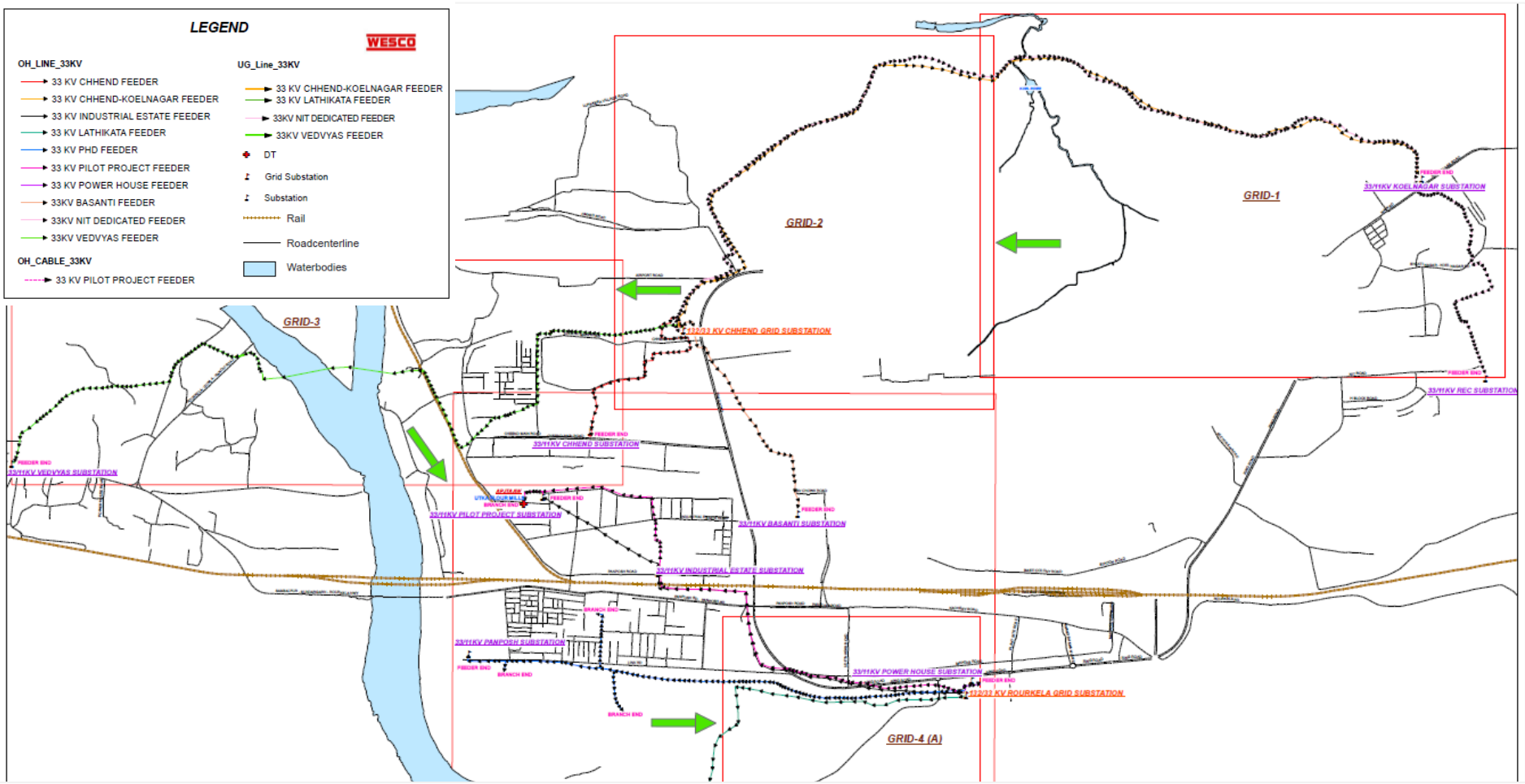


Figure 4 - Key map of smart city area

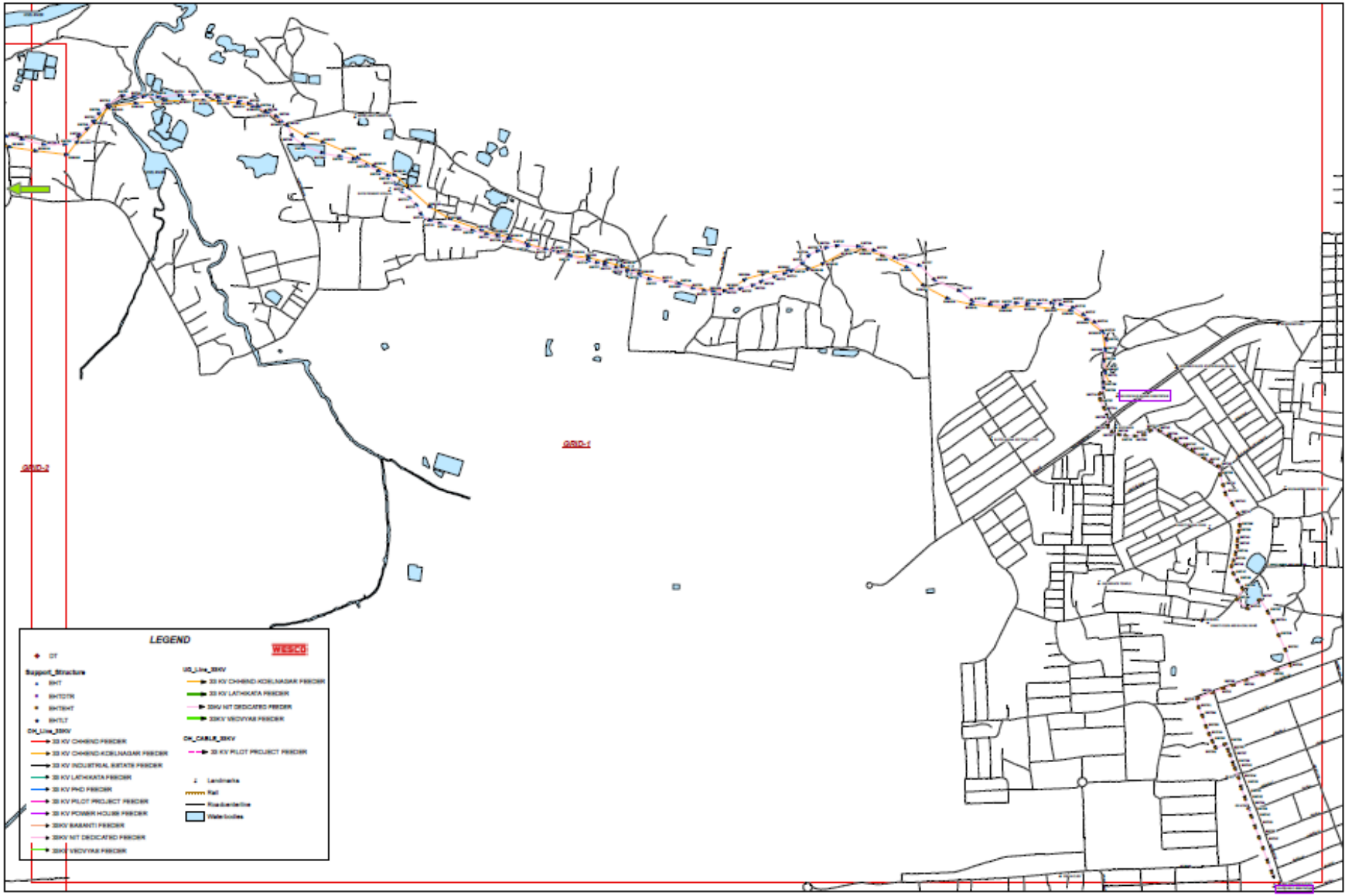


Figure 5 - Kay map of part 1

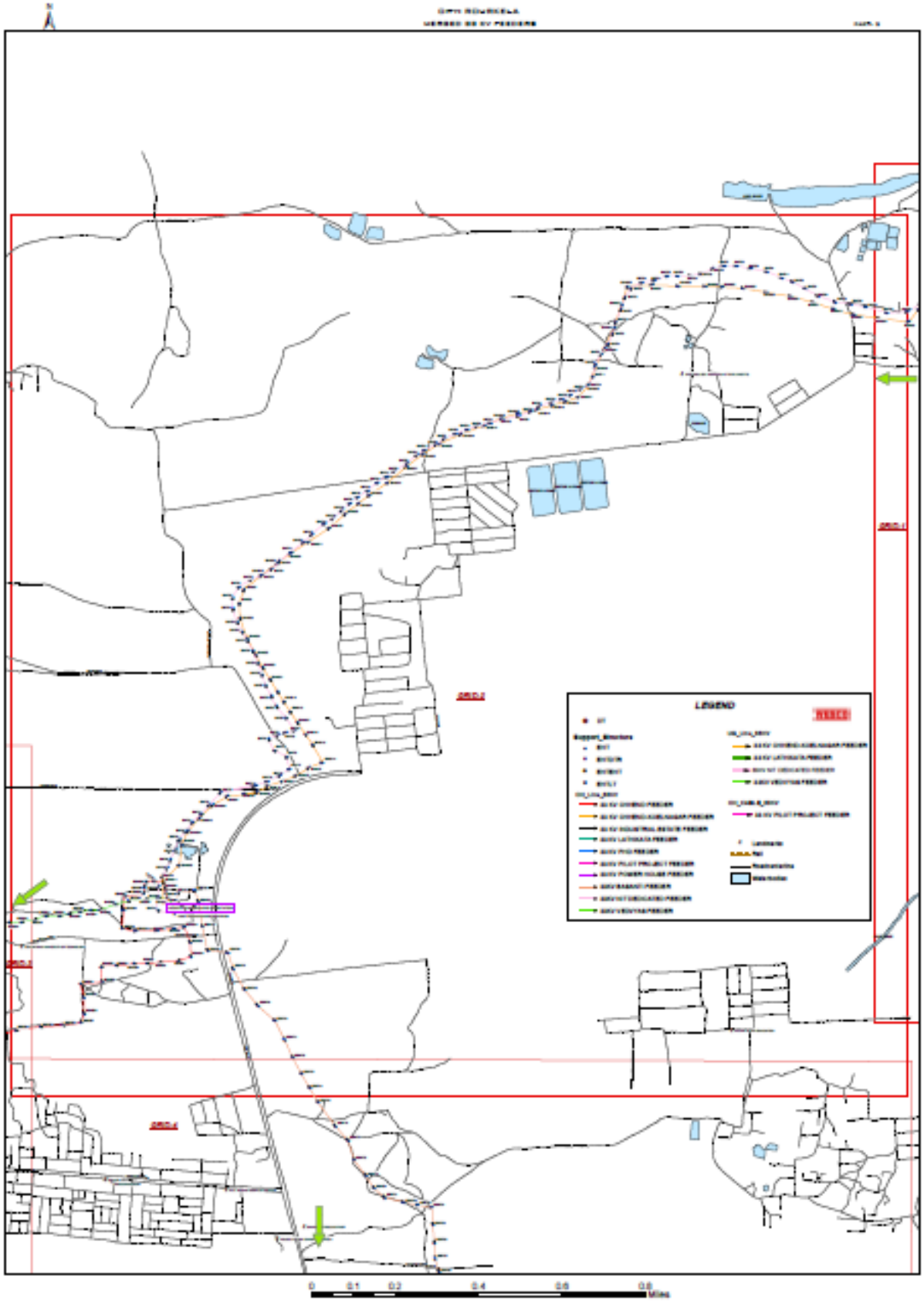


Figure 6 - Key map of Part 2

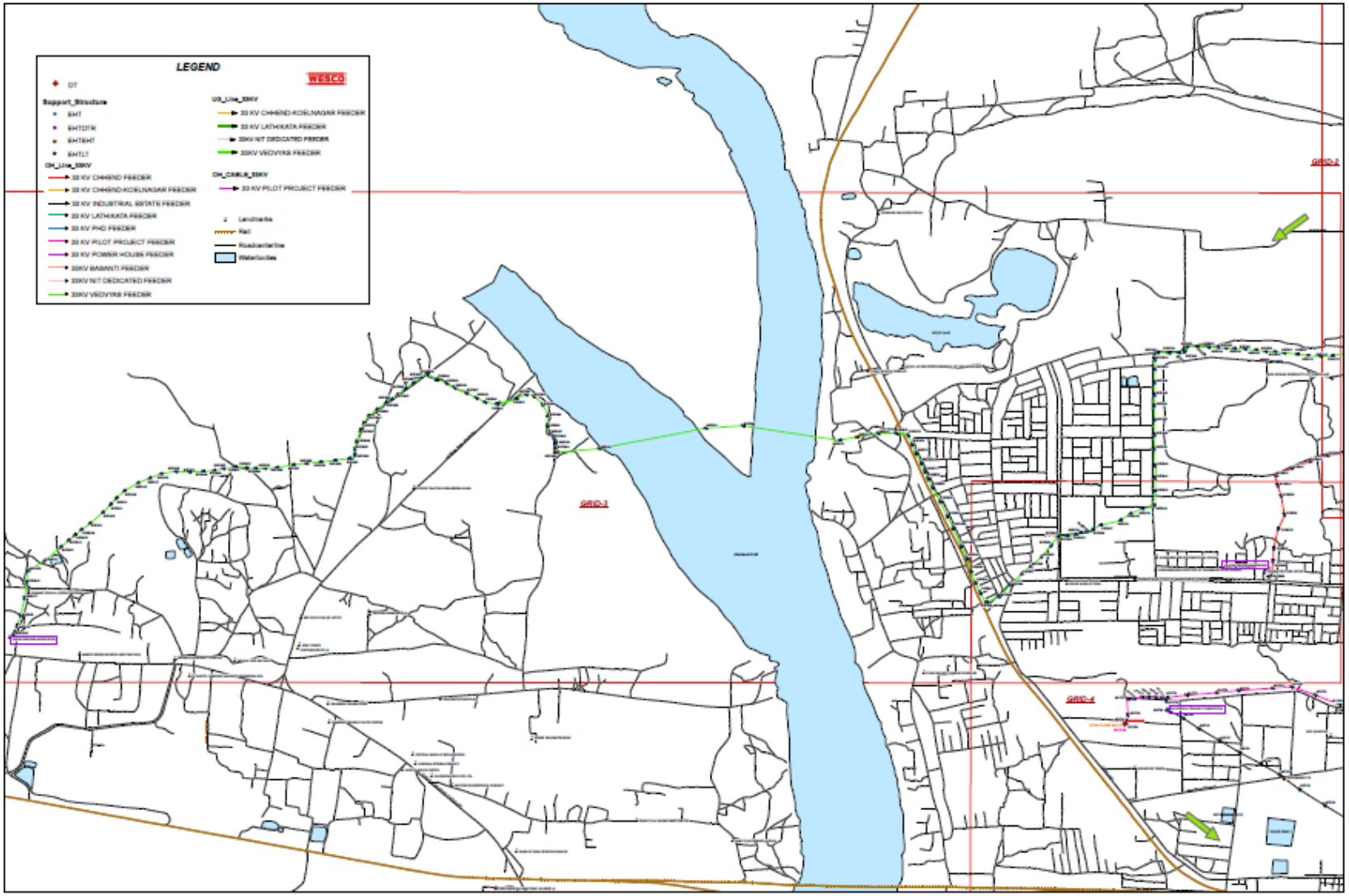


Figure 7 - Key map of Part 3

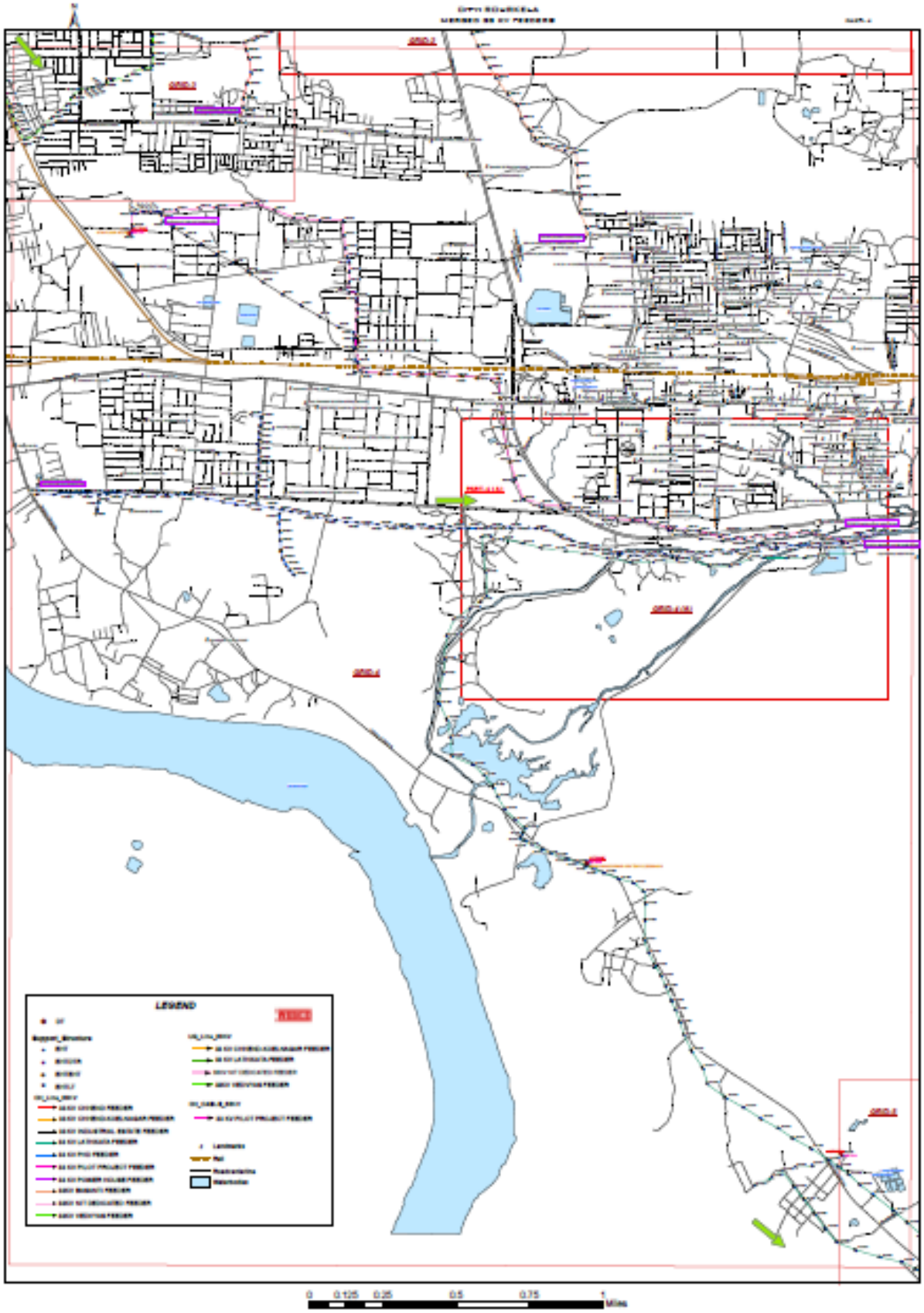


Figure 8 - Key map of Part 4

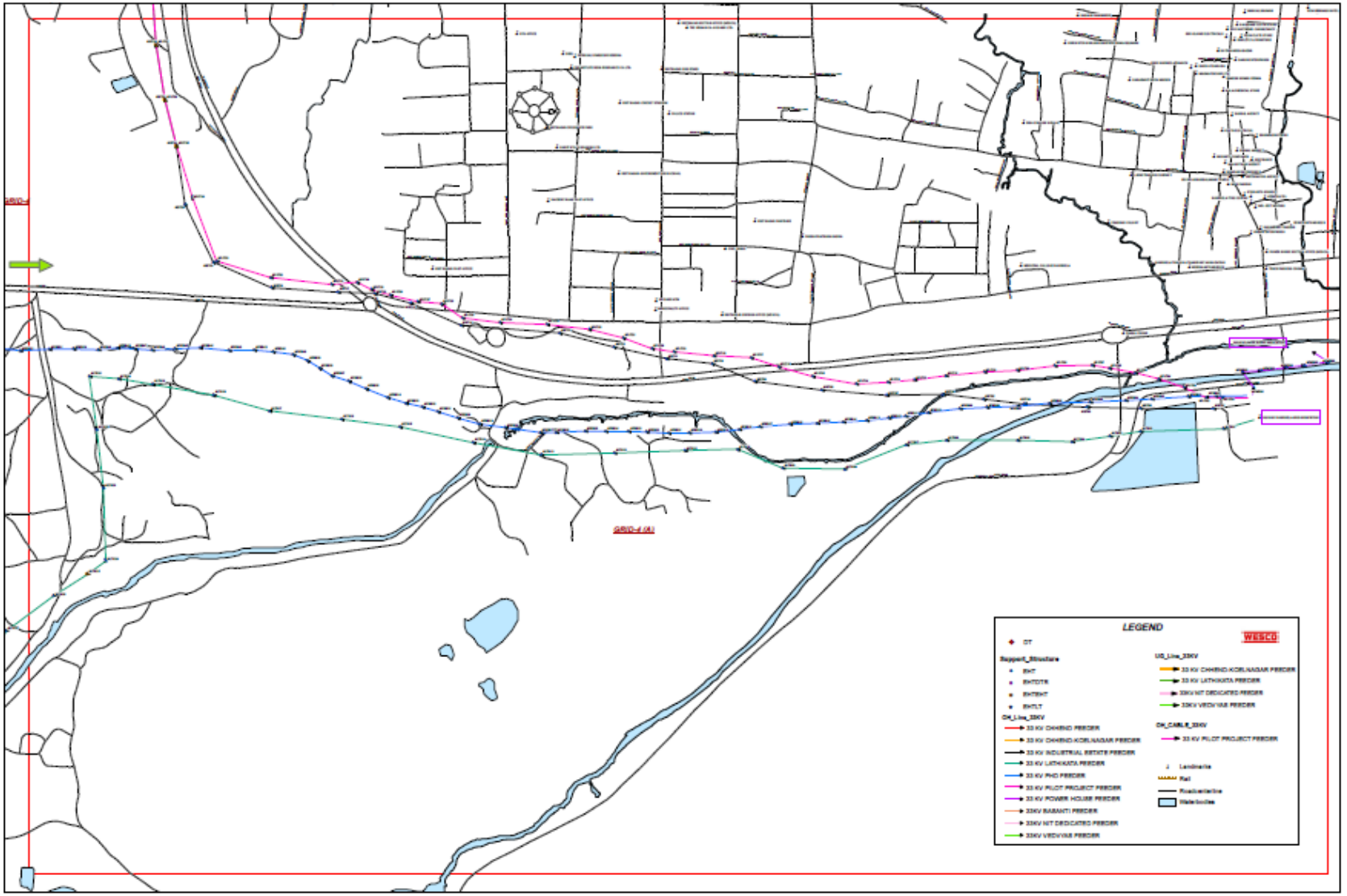


Figure 9 - Key map of Part 4A

AT&C Loss verification (FY 2017-18)

AT&C loss has been verified for all input points (33 kV and 11 kV) by the following methodology:

Step 1: Individual input of 33 kV and 11 kV feeders have been derived from feeder meter reading by the following formula:

Input Energy (Feeder A) = (Meter reading on 1st April 2018 – Meter reading on 1st April 2017) x Multiplying factor

Step 2: For each division, LT billing data is available as a database file for each month. This billing data consists of billed units, billed amount and collection for each consumer every month. As consumers are tagged with 11 kV feeders, we can derive 11 kV feeder-wise billed units, billed amount and collection from the database. Summation of billed units for connected 11 kV feeders will give the LT units billed for the 33 kV feeder. HT billing data is available as a database file for all HT consumers. A consumer list pertaining to smart city area has been shared by MRT division. This has been followed in deriving billing and collection for HT consumers. With these data, the billing efficiency of the 33 kV feeder can be derived as per the following formula:

Billing Efficiency (Feeder A) = (Billed energy of 33 kV consumers + Billed energy of 11 kV consumers + Billed energy of LT consumers of 11 kV feeders from connected substations) x 100 / Input Energy (Feeder A)

Step 3: Collection Efficiency can be determined as follows:

Collection Efficiency (Feeder A) = (Amount Collected from 33 kV consumers + Amount Collected from 11 kV consumers + Amount Collected from LT consumers of 11 kV feeders from connected substations) x 100 / (33 kV consumers billed amount + 11 kV consumers billed amount + LT consumer billed amount)

Step 4: AT & C for 33 kV feeder –

AT&C loss = 1 – (Billing efficiency x Collection efficiency) %

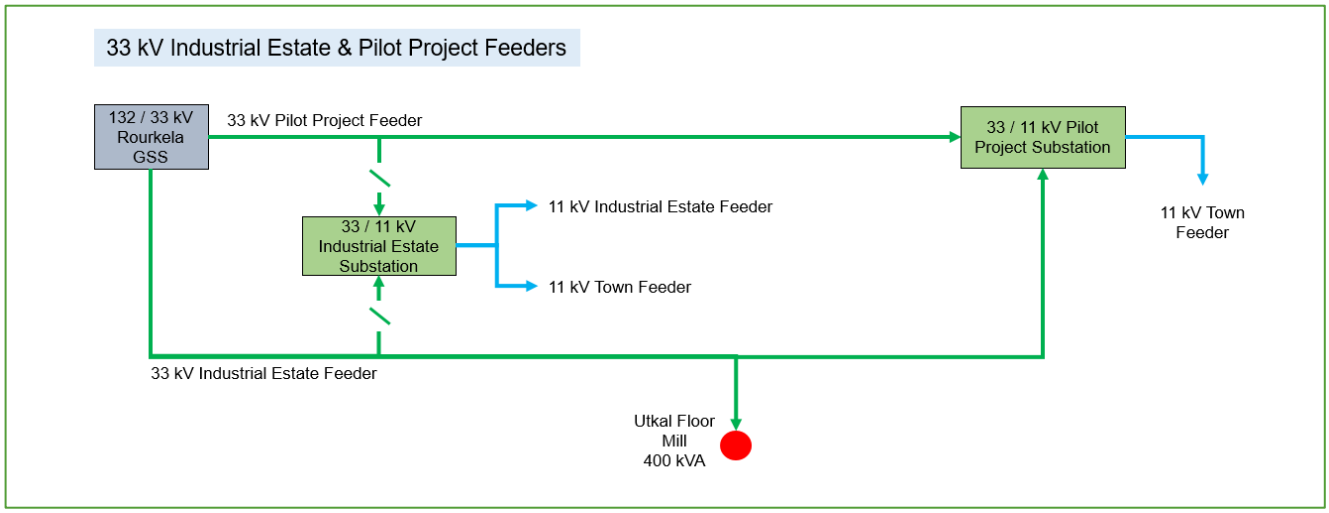
33 kV Input point feeder-wise losses

33 kV Industrial estate & 33 kV pilot project feeders

The input energy recorded for 33 kV Industrial Estate & 33 kV Pilot Project feeders can be summed up and compared with 11 kV feeders emanating from 33/11 kV Industrial Estate & Pilot Project substations in order to determine loss on 33 kV line and power transformer loss.

It is to be noted that AT&C calculation is done for the two feeders as a whole due to regular switchovers for load sharing.

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
33 kV Industrial Estate	71,04,601	75,20,804	60	249.73
33 kV Pilot Project feeder	14,29,325	15,51,167	60	45.55
Total input energy for 33 kV Industrial Estate & 33 kV Pilot Project feeder				**295.28**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes[1]. Billed units for 11 kV feeders are added from database files and the results are collated below –

[1] List of 11 kV feeders with feeder codes provided by WESCO – Annexure 1

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Pilot Project (Town)	2.87	1.34	4.23
11 kV Industrial Estate feeder	105.09	5.71	110.8
11 kV Town feeder	54.34	13.64	67.98
Total energy billed for connected consumers of 11 kV feeders			182.99
Billed energy for 33 kV consumer M/s Utkal Flour Mills			19.03
Total billed energy 33 kV consumer + 11 kV feeders			202.02
Total input energy for 33 kV Industrial Estate & 33 kV Pilot Project feeder			295.28
Billing efficiency (%)			**68.42%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Pilot Project (Town)	21.11	6.59	20.82	6.59
11 kV Industrial Estate feeder	521.49	42.63	477.17	42.63
11 kV Town feeder	330.13	93.37	419.26	93.37
33 kV Utkal Flour Mill	-	116.93	-	116.93
Total		1132.25		1176.77
Collection efficiency (%)				**103.92 %**

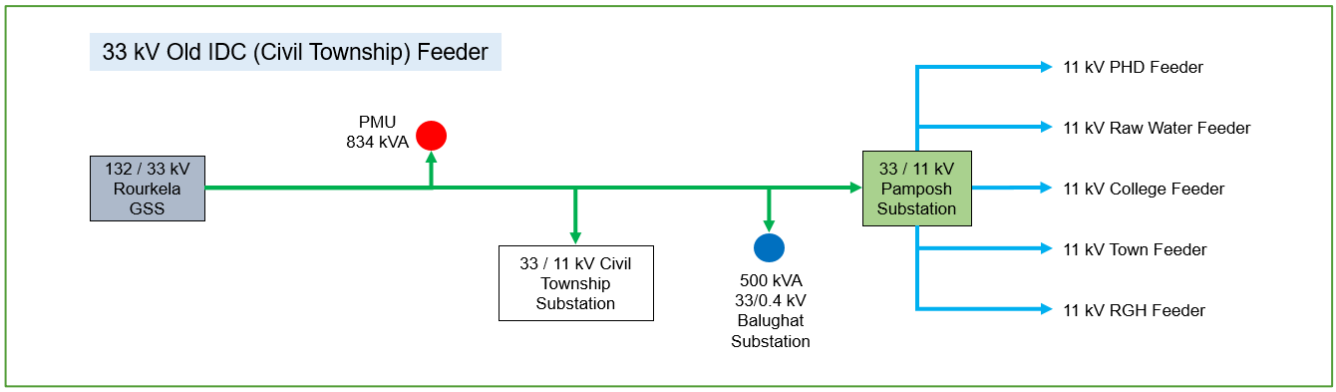
Therefore AT&C loss for 33 kV Industrial Estate & 33 kV Pilot Project feeders can be calculated as follows:

Parameter	Value
Billing efficiency (%)	68.42
Collection efficiency (%) (Capped at 100 %)	100.00
AT&C Loss	**31.58 %**

33 kV old IDC feeder

The input energy recorded for 33 kV Old IDC feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Panposh substation in order to determine loss on 33 kV line and power transformer loss.
The Input energy for 33kV IDC feeder is calculated by adding up consumptions as per the load survey data available with WESCO M.R.T division Rourkela

Feeder Name	Consumption for the month of April 2017	Cumulative consumption up to the month of April 2018	Multiplying Factor (MF)	Input Energy (LU)
33 kV Old IDC feeder	45.97	404.74	120	450.72
Total input energy for 33 kV Old IDC feeder				**450.72**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes[2]. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV PHD feeder	0.24	13.52	13.76
11 kV Raw Water feeder	23.87	35.72	59.59
11 kV College feeder	90.35	27.85	118.20
11 kV Town feeder	150.61	-	150.61
11 kV RGH feeder	-	-	-
Total energy billed for connected consumers of 11 kV feeders			342.16
Billed energy for 33 kV consumer Project Manager PMU			30.36
Billed energy for 33/0.4 kV Balughat (AGLX)			9.31
Total billed energy 33 kV consumer + 11 kV feeders			381.83
Total input energy for 33 kV Old IDC feeder			450.72
Billing efficiency (%)			**84.72 %**

[2] List of 11 kV feeders with feeder codes provided by WESCO – Annexure 1

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV PHD feeder	1.33	70.65	1.84	70.65
11 kV Raw Water feeder	135.06	219.96	118.69	219.96
11 kV College feeder	565.87	185.33	538.94	185.33
11 kV Town feeder	901.28	-	852.31	-
11 kV RGH feeder	-	-	-	-
33 kV Project Manager PMU	-	180.591	-	180.591
33/0.4 kV Balughat (AGLX)	52.57	-	39.99	-
Total		2312.64		2208.30
Collection efficiency (%)				**95.49%**

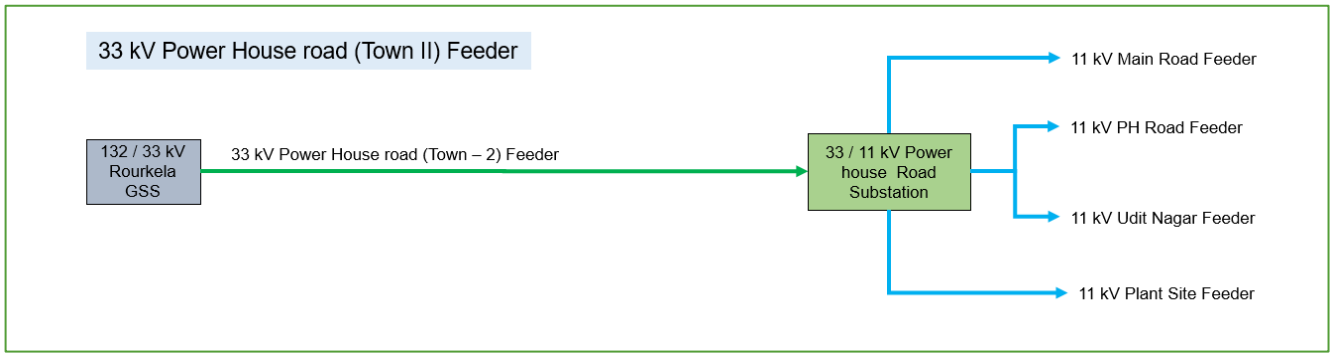
Therefore AT&C loss for 33 kV Old IDC feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	84.73
Collection efficiency (%)	95.49
AT&C Loss	**19.11 %**

33 kV Power House (Town – 2) feeder

The input energy recorded for 33 kV Town - 2 feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Power house road substation in order to determine loss on 33 kV line and power transformer loss.

Feeder Name	Reading as on 1st April 2017	Reading as on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
33 kV Town-2 Feeder	90,30,284	95,94,298	120	676.81
Total input energy for 33 kV Town - 2 feeder				**676.81**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes[3]. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Udit Nagar feeder	133.49	22.69	156.18
11 kV Main Road feeder	121.73	75.01	196.74
11 kV Power house road	58.85	0	58.85
11 kV Plant Site feeder	106.59	2.62	109.21
Total energy billed for connected consumers of 11 kV feeders			520.98
Total input energy for 33 kV Town - 2 feeder			676.81
Billing efficiency (%)			**76.98%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Udit Nagar feeder	718.36	137.02	734.93	137.02
11 kV Main Road feeder	641.13	486.05	688.66	486.05
11 kV Power house road	274.13	0	283.71	0
11 kV Plant Site feeder	516.54	24.1	466.78	24.1
Total	2797.33		2821.25	
Collection efficiency (%)				**100.86%**

Therefore AT&C loss for 33 kV Town - 2 feeder can be calculated as follows:

[3] List of 11 kV feeders with feeder codes provided by WESCO – Annexure 1

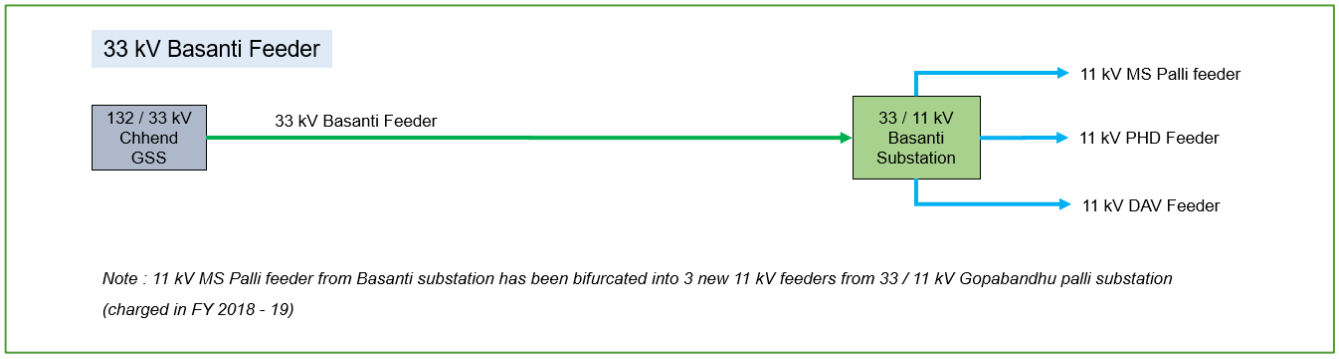
Parameter	Value
Billing efficiency (%)	76.98
Collection efficiency (%) (Capped at 100 %)	100.00
AT&C Loss	**23.02%**

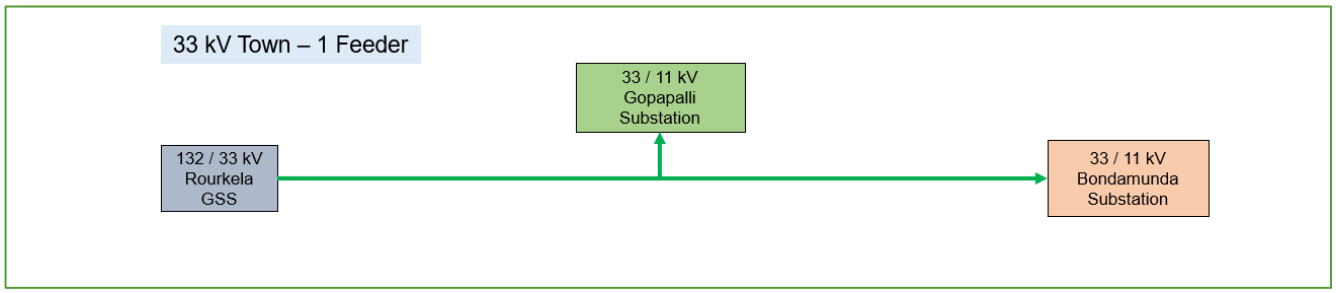
It may be noted that according to PFC guidelines Collection efficiency shall be considered not more than 100% while computing AT&C losses.

33 kV Basanti feeder

The input energy recorded for 33 kV Basanti feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Basanti substation in order to determine loss on 33 kV line and power transformer loss.

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
33 kV Basanti feeder	7,17,909	15,01,286	60	470.03
Total input energy for 33 kV Basanti feeder				**470.03**





Billed units of all 11 kV feeders can be summed up as per the list of feeder codes. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV DAV feeder	117	0	117
11 kV PHD feeder	48.28	1.75	50.03
11 kV MS Palli feeder	117.62	2.05	119.67
Total energy billed for connected consumers of 11 kV feeders			286.70
Total input energy for 33 kV Basanti & Town 1 feeder			470.03
Billing efficiency (%)			**61.00%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV DAV feeder	492.67	-	477.42	-
11 kV PHD feeder	231.16	12.19	235.53	12.19
11 kV MS Palli feeder	507.89	14.89	254.25	14.89
Total		1258.80		994.28
Collection efficiency (%)				**78.98%**

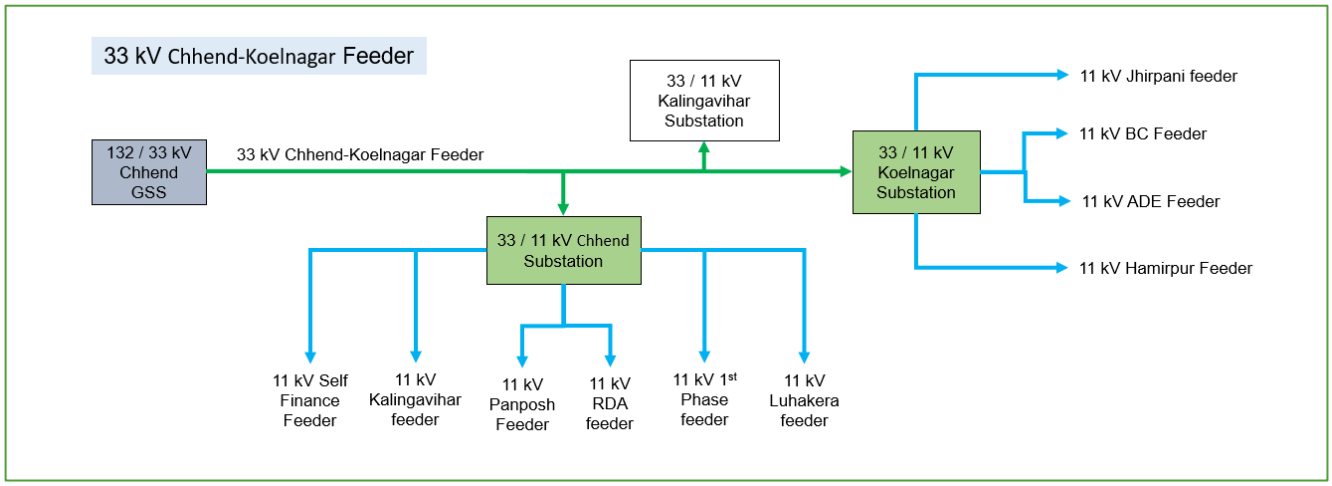
Therefore AT&C loss for 33 kV Basanti & Town – 1 feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	61.00
Collection efficiency (%)	78.98
AT&C Loss	**51.82%**

33 kV Chhend-Koelnagar feeder

The input energy recorded for 33 kV Chhend-Koelnagar feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Chhend and 33/11 kV Koelnagar substations in order to determine loss on 33 kV line and power transformer loss. The Chhend Loelnagar feeder is also connected to 33/11 kV Kalingavihar Substation. So the effective input for the smart city area

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
33 kV Chhend-Koelnagar	180,90,580	187,21,100	120	756.62
Total input energy for 33 kV Chhend-Koelnagar feeder				**756.62**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Jhirpani feeder	48.10	5.77	53.87
11 kV BC Block feeder	51.15	-	51.15
11 kV ADE Block feeder	80.37	-	80.37
11 kV Hamirpur feeder	36.65	-	36.65
11 kV Self Finance feeder	54.84	1.49	56.33
11 kV Panposh feeder	52.33	3.02	55.35
11 kV RDA feeder	35.39	2.50	37.89
11 kV Chhend 1st Phase	73.08		73.08
11 kV Kalinga Vihar	61.05		61.05
11 kV Luhakera	23.21	5.64	28.84
Total energy billed for connected consumers of 11 kV feeders			534.59
Total input energy for 33 kV Chhend-Koelnagar feeder			756.62
Billing efficiency (%)			**70.65 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Jhirpani feeder	215.01	37.58	190.95	37.58
11 kV BC Block feeder	228.81	-	248.89	-
11 kV ADE Block feeder	383.12	-	415.99	-

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Hamirpur feeder	155.25	-	153.65	-
11 kV Self Finance feeder	280.24	13.35	262.45	13.35
11 kV Panposh feeder	271.62	23.24	218.99	23.24
11 kV RDA feeder	170.14	13.35	154.94	13.35
11 kV Chhend 1st Phase	368.13	-	336.46	-
11 kV Kalinga Vihar	305.08	-	278.53	-
11 kV Luhakera	119.66	24.50	60.90	24.50
Total		**2609.08**		**2433.77**
Collection efficiency (%)				**93.28 %**

Therefore AT&C loss for 33 kV Chhend-Koelnagar feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	70.65
Collection efficiency (%)	93.28
AT&C Loss	**34.09 %**

11 kV Input point feeder-wise losses

11 kV Modern India - 1 feeder

11 kV Modern India – 1 feeder emanates from 33/11 kV Lathikata substation which in turn is supplied power through 33 kV Lathikata feeder from 132/33 kV Rourkela GSS. While other feeders from 33/11 kV Lathikata substation cater to areas outside smart city, 11 kV Modern India – 1 (partially) caters to Rourkela Smart city area. Input energy of the feeder is calculated as follows:
The total transformation capacity installed on the feeder is 8000kVA, out of that around 800kVA of transformation capacity falls under the smart city area. Therefore the input billing and collection is proportioned to be 10% of the total figures of the feeder as whole.

Feeder Name	Input Energy (LU)
11 kV Modern India - I feeder	11.47

Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Modern India - I (AIAA)	9.08	-	9.08
Total input energy for 11 kV Modern India - 1 feeder			11.47
Billing efficiency (%)			**79.00 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Modern India - I (AIAA)	39.50	-	41.17	-
Total		39.50		41.17
Collection efficiency (%)				**104.22 %**

Therefore AT&C loss for 11 kV Modern India – 1 feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	79.00 %
Collection efficiency (%)(Capped at 100%)	100.00 %
AT&C Loss	**21.00 %**

11 kV Ved Vyas feeder

11 kV Vedvyas feeder emanates from 33/11 kV Vedvyas substation which in turn is supplied power through 33 kV Vedvyas feeder from 132/33 kV Chhend GSS. While other feeders from 33/11 kV Vedvyas substation cater to areas outside smart city, 11 kV Vedvyas and 11 kV Gopapalli feeders caters to Rourkela Smart city area. Input energy of the feeder is calculated as follows:

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
11 kV Vedvyas feeder	5258.61	5,867.71	20000	121.82
Total input energy for 11 kV Vedvyas feeder				**121.82**

Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Vedvyas (BDCC)	78.21	25.87	104.08
Total input energy for 11 kV Vedvyas feeder			121.82
Billing efficiency (%)			**85.44 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Vedvyas (BDCC)	457.65	177.21	454.36	177.21
Total		634.86		631.57
Collection efficiency (%)				**99.48 %**

Therefore AT&C loss for 11 kV Vedvyas feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	85.44
Collection efficiency (%)	99.48
AT&C Loss	**15.00 %**

11 kV Gopapalli feeder

11 kV Gopapalli feeder emanates from 33/11 kV Vedvyas substation which in turn is supplied power through 33 kV Vedvyas feeder from 132/33 kV Chhend GSS. While other feeders from 33/11 kV Vedvyas substation cater to areas outside smart city, 11 kV Vedvyas and 11 kV Gopapalli feeders caters to Rourkela Smart city area. Input energy of the feeder is calculated as follows:

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
11 kV Gopapalli feeder	11,029.88	11,340.44	20000	62.11
Total input energy for 11 kV Gopapalli feeder				**62.11**

Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Gopapalli (BDCB)	25.77	10.51	36.28
Total input energy for 11 kV Gopapalli feeder			62.11
Billing efficiency (%)			**58.41 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Gopapalli (BDCB)	148.46	69.79	142.57	69.79
Total		218.25		212.36
Collection efficiency (%)				**97.30 %**

Therefore AT&C loss for 11 kV Gopapalli feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	58.41
Collection efficiency (%)	97.30
AT&C Loss	**43.16 %**

11 kV Nayabazar feeder

11 kV Nayabazar feeder emanates from 33/11 kV REC substation which in turn is supplied power through 33 kV NIT feeder from 132/33 kV Chhend GSS. All three feeders from 33/11 kV REC substation cater to areas within smart city. Input energy of 11 kV Nayabazar feeder is calculated as follows:

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
11 kV Nayabazar feeder	59,487.23	63,169.79	4000	147.30
Total input energy for 11 kV Nayabazar feeder				**147.30**

Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Nayabazar (AAAA)	91.91	5.3	97.21
Total input energy for 11 kV Nayabazar feeder			147.30
Billing efficiency (%)			**65.99 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Nayabazar (AAAA)	381.92	27.01	355.02	27.01
Total	408.93		382.03	
Collection efficiency (%)				**93.42 %**

Therefore AT&C loss for 11 kV Nayabazar feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	65.99
Collection efficiency (%)	93.42
AT&C Loss	**38.35 %**

11 kV OSAP feeder

11 kV OSAP feeder emanates from 33/11 kV REC substation which in turn is supplied power through 33 kV NIT feeder from 132/33 kV Chhend GSS. All three feeders from 33/11 kV REC substation cater to areas within smart city. Input energy of 11 kV OSAP feeder is calculated as follows:

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
11 kV OSAP feeder	29,020.87	30,920.86	6000	113.99
Total input energy for 11 kV OSAP feeder				**113.99**

Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV OSAP (AAAD)	69.92	-	69.92
Total input energy for 11 kV OSAP feeder			113.99
Billing efficiency (%)			**61.33 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV OSAP (AAAD)	320.47	-	314.41	-
Collection efficiency (%)				98.11%

Therefore AT&C loss for 11 kV OSAP feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	61.33
Collection efficiency (%)	98.11
AT&C Loss	**39.82 %**

It may be noted that according to the guidelines Collection efficiency shall be considered not more than 100% while computing AT&C losses.

11 kV Shaktinagar feeder

11 kV Shaktinagar feeder emanates from 33/11 kV REC substation which in turn is supplied power through 33 kV NIT feeder from 132/33 kV Chhend GSS. All three feeders from 33/11 kV REC substation cater to areas within smart city. Input energy of 11 kV Shaktinagar feeder is calculated as

Feeder Name	Reading on 1st April 2017	Reading on 1st April 2018	Multiplying Factor (MF)	Input Energy (LU)
11 kV Shaktinagar Feeder	9759.82	15956.4	1500	92.95
Total input energy for 11 kV Shaktinagar feeder				**92.95**

Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Shaktinagar (AAAB)	74.35	3.08	77.43
Total input energy for 11 kV Shaktinagar feeder			92.95
Billing efficiency (%)			**83.30%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Shaktinagr (AAAB)	354.57	22.67	372.09	22.67
Collection efficiency (%)				**104.60%**

Therefore AT&C loss for 11 kV Shaktinagar feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	83.30
Collection efficiency (%) (Capped at 100%)	100.00
AT&C Loss	**16.70%**

It may be noted that according to the guidelines Collection efficiency shall be considered not more than 100% while computing AT&C losses.

Total Input energy into the smart city area

Sl. No.	Feeder Name	Input Energy (LU)
1	33 kV Industrial Estate feeder	249.72
2	33 kV Pilot Project feeder	45.55
3	33 kV Old IDC feeder	450.72
4	33 kV Town - 2 feeder	676.81
5	33 kV Basanti feeder	470.03
6	33 kV Town–1 feeder	
7	33 kV Chhend-Koelnagar feeder	756.62
8	11 kV Modern India - I feeder	11.47
9	11 kV Vedvyas feeder	121.82
10	11 kV Gopapalli feeder	62.11
11	11 kV Nayabazar feeder	147.3
12	11 kV OSAP feeder	113.99
13	11 kV Shaktinagar feeder	92.95
Total input energy for Rourkela smart city (FY 2017-18)		**3,199.09**

Billed energy booked under the smart city area

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Pilot Project (Town)	2.87	1.34	4.21
11 kV Industrial Estate feeder	105.09	5.71	110.8
11 kV Town feeder	54.34	13.64	67.98
11 kV PHD feeder	0.24	13.52	13.76
11 kV Raw Water feeder	23.87	35.72	59.59
11 kV College feeder	90.35	27.85	118.2
11 kV Town feeder	150.61	0	150.61
11 kV RGH feeder	0	0	0
11 kV Udit Nagar feeder	133.49	22.69	156.18
11 kV Main Road feeder	121.73	75.01	196.74
11 kV Power house road	58.85	0	58.85

11 kV Plant Site feeder	106.59	2.62	109.21
11 kV DAV feeder	117	0	117
11 kV PHD feeder	48.28	1.75	50.03
11 kV MS Palli feeder	117.62	2.05	119.67
11 kV Jhirpani feeder	48.1	5.77	53.87
11 kV BC Block feeder	51.15	0	51.15
11 kV ADE Block feeder	80.37	0	80.37
11 kV Hamirpur feeder	36.65	0	36.65
11 kV Self Finance feeder	54.84	1.49	56.33
11 kV Panposh feeder	52.33	3.02	55.35
11 kV RDA feeder	35.39	2.5	37.89
11 kV Chhend 1st Phase	73.08		73.08
11 kV Kalinga Vihar	61.05		61.05
11 kV Luhakera	23.21	5.64	28.85
11 kV Modern India - I (AIAA)	9.08	0	9.08
11 kV Vedvyas (BDCC)	78.21	25.87	104.08
11 kV Gopapalli (BDCB)	25.77	10.51	36.28
11 kV Nayabazar (AAAA)	91.91	5.3	97.21
11 kV OSAP (AAAD)	69.92	0	69.92
11 kV Shaktinagar (AAAB)	74.35	3.08	77.43
Total LT & 11 kV HT	1996.34	265.08	2261.42
Total energy billed for connected consumers of 11 kV feeders			2261.42
Billed energy for 33 kV consumers and DT			58.7
Total billed energy 33 kV consumer + 11 kV feeders			2,320.12
Total input energy			3,199.09
Billing efficiency (%)			**72.52%**

Billed units for HT consumers

Sl. No.	Consumer Name	Billed Energy (LU)
1	Utkal Flour Mills	19.03
2	Project Manager (PMU)	30.36

Sl. No.	Consumer Name	Billed Energy (LU)
3	33/0.4 kV Balughat transformer	9.31

Collection booked under the smart city area

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
33 kV Utkal Flour Mill	0	116.93	0	116.93
33 kV Project Manager PMU	0	180.591	0	180.591
33/0.4 kV Balughat (AGLX)	52.57	0	39.99	0
11 kV Pilot Project (Town)	21.11	6.59	20.82	6.59
11 kV Industrial Estate feeder	521.49	42.63	477.17	42.63
11 kV Town feeder	330.13	93.37	419.26	93.37
11 kV PHD feeder	1.33	70.65	1.84	70.65
11 kV Raw Water feeder	135.06	219.96	118.69	219.96
11 kV College feeder	565.87	185.33	538.94	185.33
11 kV Town feeder	901.28	-	852.31	-
11 kV RGH feeder				
11 kV DAV feeder	492.67	0	477.42	0
11 kV PHD feeder	231.16	12.19	235.53	12.19
11 kV MS Palli feeder	507.89	14.89	254.25	14.89
11 kV Jhirpani feeder	215.01	37.58	190.95	37.58
11 kV BC Block feeder	228.81	0	248.89	0
11 kV ADE Block feeder	383.12	0	415.99	0
11 kV Hamirpur feeder	155.25	0	153.65	0
11 kV Self Finance feeder	280.24	13.35	262.45	13.35
11 kV Panposh feeder	271.62	23.24	218.99	23.24
11 kV RDA feeder	170.14	13.35	154.94	13.35
11 kV Chhend 1st Phase	368.13	0	336.46	0
11 kV Kalinga Vihar	305.08	0	278.53	0
11 kV Luhakera	119.66	24.5	60.9	24.5
11 kV Udit Nagar feeder	718.36	137.02	734.93	137.02
11 kV Main Road feeder	641.13	486.05	688.66	486.05

11 kV Power house road	274.13	0	283.71	0
11 kV Plant Site feeder	516.54	24.1	466.78	24.1
11kV Modern India 1	39.5	0	41.17	0
11 kV Vedvyas (BDCC)	457.65	177.21	454.36	177.21
11 kV Gopapalli (BDCB)	148.46	69.79	142.57	69.79
11 kV Nayabazar (AAAA)	381.92	27.01	355.02	27.01
11 kV OSAP (AAAD)	320.47	0	314.41	0
11 kV Shaktinagar	354.57	22.67	372.09	22.67
Total	12109.35		11610.67	
Collection efficiency (%)				**95.88%**

The total AT&C losses, input feeder wise in Rourkela Smart City area as a whole under WESCO Rourkela circle for FY 2017-18 is tabulated below:

Sl. No.	Feeder Name	Input Energy (LU)	Billed Energy (LU)	Billed Amount(Lacs)	Collected amount(Lacs)	Billing Efficiency	Collection Efficiency	AT&C
		a	b	c	d	e=b/a	f=d/c	g=1-e*f
1	33 kV Industrial Estate feeder	249.72	202.02	1132.25	1176.77	68%	104%	32%
2	33 kV Pilot Project feeder	45.55						
3	33 kV Old IDC feeder	450.72	381.83	2312.64	2208.30	85%	95%	19%
4	33 kV Town - 2 feeder	676.81	520.98	2797.33	2821.25	77%	101%	23%
5	33 kV Basanti feeder	470.03	286.70	1258.80	994.28	61%	79%	52%
6	33 kV Town–1 feeder							
7	33 kV Chhend-Koelnagar feeder	756.62	534.59	2609.08	2433.77	71%	93%	34%
8	11 kV Modern India - I feeder	11.47	9.08	39.50	41.17	79%	104%	21%
9	11 kV Vedvyas feeder	121.82	104.08	634.86	631.57	85%	99%	15%
10	11 kV Gopapalli feeder	62.11	36.28	218.25	212.36	58%	97%	43%
11	11 kV Nayabazar feeder	147.3	97.21	408.93	382.03	66%	93%	38%
12	11 kV OSAP feeder	113.99	69.92	320.47	314.41	61%	98%	40%
13	11 kV Shaktinagar feeder	92.95	77.43	377.24	394.76	83%	105%	17%
Total for Rourkela smart city area (FY 2017-18)		**3,199.09**	**2,320.12**	**12,109.35**	**11,610.67**	**73%**	**96%**	**30%**

AT&C Loss verification (FY 2018-19)

AT&C loss has been verified for all input points (33 kV and 11 kV) by the following methodology:

Step 1: Individual input of 33 kV and 11 kV feeders have been derived from feeder meter reading by the following formula:

Input Energy (Feeder A) = (Meter reading on 1st April 2019 – Meter reading on 1st April 2018) x Multiplying factor

Step 2: For each division, LT billing data is available as a database file for each month. This billing data consists of billed units, billed amount and collection for each consumer every month. As consumers are tagged with 11 kV feeders, we can derive 11 kV feeder-wise billed units, billed amount and collection from the database. Summation of billed units for connected 11 kV feeders will give the LT units billed for the 33 kV feeder. HT billing data is available as a database file for all HT consumers. A consumer list pertaining to smart city area has been shared by MRT division. This has been followed in deriving billing and collection for HT consumers. With these data, the billing efficiency of the 33 kV feeder can be derived as per the following formula:

Billing Efficiency (Feeder A) = (Billed energy of 33 kV consumers + Billed energy of 11 kV consumers + Billed energy of LT consumers of 11 kV feeders from connected substations) x 100 / Input Energy (Feeder A)

Step 3: Collection Efficiency can be determined as follows:

Collection Efficiency (Feeder A) = (Amount Collected from 33 kV consumers + Amount Collected from 11 kV consumers + Amount Collected from LT consumers of 11 kV feeders from connected substations) x 100 / (33 kV consumers billed amount + 11 kV consumers billed amount + LT consumer billed amount)

Step 4: AT & C for 33 kV feeder –

AT&C loss = 1 – (Billing efficiency x Collection efficiency) %

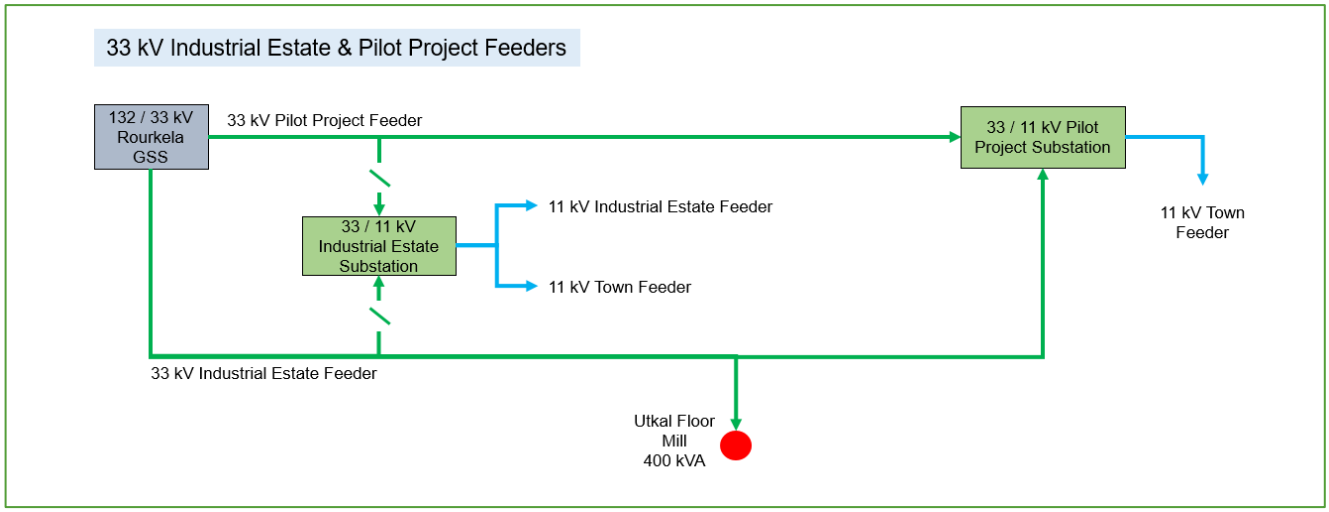
33 kV Input point feeder-wise losses

33 kV Industrial estate & 33 kV pilot project feeders

The input energy recorded for 33 kV Industrial Estate & 33 kV Pilot Project feeders can be summed up and compared with 11 kV feeders emanating from 33/11 kV Industrial Estate & Pilot Project substations in order to determine loss on 33 kV line and power transformer loss.

It is to be noted that AT&C calculation is done for the two feeders as a whole due to regular switchovers for load sharing throughout FY 18-19.

Feeder Name	Reading on 1st April 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
33 kV Industrial Estate	75,20,804	79,00,714	60	227.95
33 kV Pilot Project feeder	15,05,249	15,67,666	60	37.45
Input energy for 33 kV Industrial Estate & 33 kV Pilot Project feeder				**265.40**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes[4]. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Pilot Project (Town)	3.33	1.09	4.42
11 kV Industrial Estate feeder	123.56	6.40	129.96
11 kV Town feeder	38.06	15.41	53.47

[4] List of 11 kV feeders with feeder codes provided by WESCO – Annexure 1

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
Total energy billed for connected consumers of 11 kV feeders			187.86
Billed energy for 33 kV consumer M/s Utkal Flour Mills			18.80
Total billed energy 33 kV consumer + 11 kV feeders			206.66
Total input energy for 33 kV Industrial Estate & 33 kV Pilot Project feeder			265.40
Billing efficiency (%)			**77.87 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Pilot Project (Town)	24.60	6.59	27.09	6.59
11 kV Industrial Estate feeder	710.36	44.22	687.54	44.22
11 kV Town feeder	235.90	106.64	209.02	106.64
33 kV Utkal Flour Mill	-	118.92	-	118.92
Total		1247.23		1200.02
Collection efficiency (%)				**96.21 %**

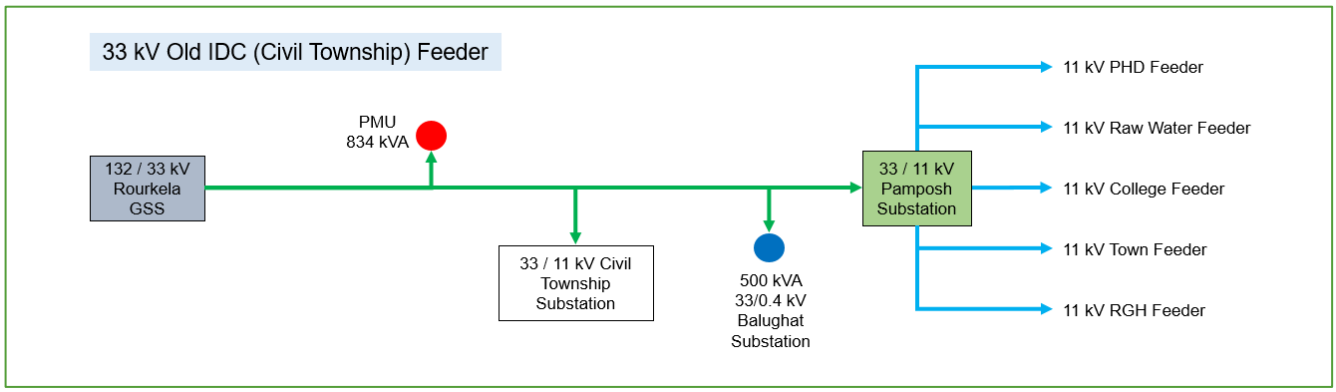
Therefore AT&C loss for 33 kV Industrial Estate & 33 kV Pilot Project feeders can be calculated as follows:

Parameter	Value
Billing efficiency (%)	77.87 %
Collection efficiency (%)	96.21 %
AT&C Loss	**25.08 %**

33 kV old IDC feeder

The input energy recorded for 33 kV Old IDC feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Panposh substation in order to determine loss on 33 kV line and power transformer loss.
The Input energy for 33kV IDC feeder is calculated by adding up consumptions as per the load survey data available with WESCO M.R.T division Rourkela

Feeder Name	Reading on 1st April 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
33 kV Old IDC feeder	43,05,320	46,70,309.00	120	437.99
Total input energy for 33 kV Old IDC feeder				**437.99**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes[5]. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV PHD feeder	0.42	15.37	15.79
11 kV Raw Water feeder	24.29	32.88	57.17
11 kV College feeder	92.82	29.38	122.20
11 kV Town feeder	161.56	-	161.56
11 kV RGH feeder	-	-	-
Total energy billed for connected consumers of 11 kV feeders			356.73
Billed energy for 33 kV consumer Project Manager PMU			33.47
Billed energy for 33/0.4 kV Balughat (AGLX)			8.73
Total billed energy 33 kV consumer + 11 kV feeders			398.92
Total input energy for 33 kV Old IDC feeder			437.99
Billing efficiency (%)			**91.08%**

[5] List of 11 kV feeders with feeder codes provided by WESCO – Annexure 1

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV PHD feeder	1.99	87.19	2.24	87.19
11 kV Raw Water feeder	134.35	196.62	128.88	196.62
11 kV College feeder	572.95	199.18	581.54	199.18
11 kV Town feeder	959.25	-	974.35	-
11 kV RGH feeder	-	-	-	-
33 kV Project Manager PMU	-	189.10	-	189.10
33/0.4 kV Balughat (AGLX)	48.98	-	56.63	-
Total		2389.61		2415.73
Collection efficiency (%)				**101.09 %**

Therefore AT&C loss for 33 kV Old IDC feeder can be calculated as follows:

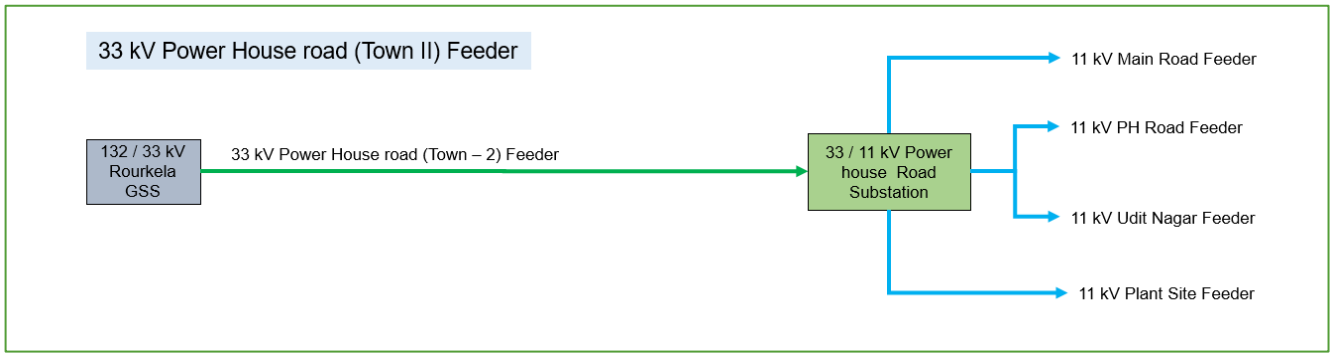
Parameter	Value
Billing efficiency (%)	91.08 %
Collection efficiency (%) (Capped at 100%)	100.00 %
AT&C Loss	**8.92 %**

33 kV Power House (Town – 2) feeder

The input energy recorded for 33 kV Town - 2 feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Power house road substation in order to determine loss on 33 kV line and power transformer loss.

The meter for the said feeder was replaced on December 2018, new readings were available from January 2019. The consumption of December (4167360 units) was calculated based on the readings that MRT department has obtained from Substation log-book.

Feeder Name	Reading as on 1st April 2018	Reading as on 1st December 2019	Multiplying Factor (MF)	Input Energy (LU)
33 kV Town-2 Feeder	95,94,298	99,87,757	120	472.15
	Reading as on 1st January 2018	**Reading as on 1st April 2019**	**Multiplying Factor (MF)**	**Input Energy (LU)**
	22,104	1,30,057	120	129.54
Total input energy for 33 kV Town - 2 feeder = (129.54 + 472.15 + 41.67)				**643.37**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes[6]. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Udit Nagar feeder	136.53	20.27	156.80
11 kV Main Road feeder	127.63	67.20	194.83
11 kV Power house road	64.14	-	64.14
11 kV Plant Site feeder	118.56	2.22	120.78
Total energy billed for connected consumers of 11 kV feeders			536.56
Total input energy for 33 kV Town - 2 feeder			643.37
Billing efficiency (%)			**83.40 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Udit Nagar feeder	832.36	125.80	791.79	125.80
11 kV Main Road feeder	785.06	428.58	745.71	428.58
11 kV Power house road	369.39	-	391.97	-
11 kV Plant Site feeder	668.76	17.89	588.25	17.89
Total		3227.84		3089.99
Collection efficiency (%)				**95.73 %**

[6] List of 11 kV feeders with feeder codes provided by WESCO – Annexure 1

Therefore AT&C loss for 33 kV Town - 2 feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	83.40%
Collection efficiency (%)	95.73%
AT&C Loss	**20.16 %**

It may be noted that according to PFC guidelines Collection efficiency shall be considered not more than 100% while computing AT&C losses.

33 kV Basanti feeder

The input energy recorded for 33 kV Basanti feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Basanti substation in order to determine loss on 33 kV line and power transformer loss.

From May 2018 onwards Basanti feeder started drawing power from 33kV Town 1 feeder as it was commissioned and charged on the same month. The total energy input to 33kV Town 1 feeder is a sum of power drawn by 11kV Nayabazar and 33kV Basanti feeder.
The quantum of energy drawn by 11kV Nayabazar feeder from 33kV town 1 is equal to that of 11kV Bondamunda feeder emanating from 33/11kV Bondamunda Substation (11kV Nayabazar and Bondamunda were connected from May 2018).

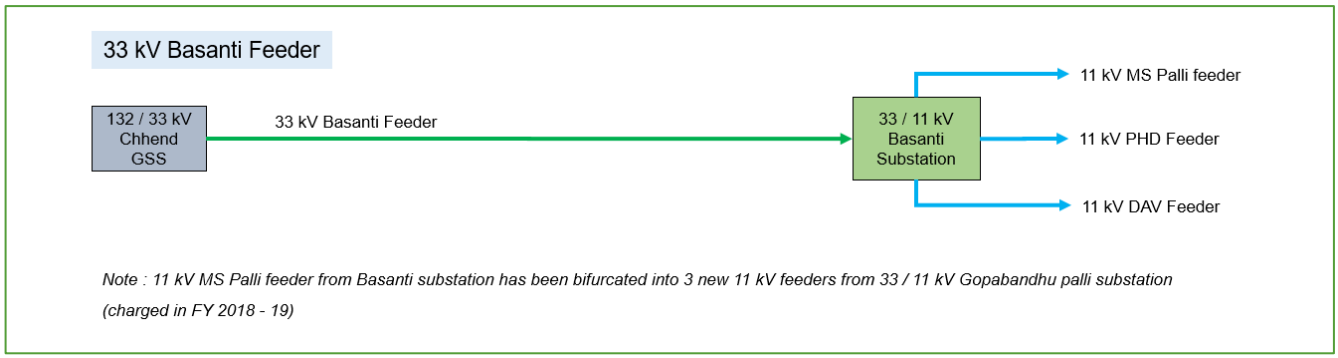
Therefore the calculation stands as:

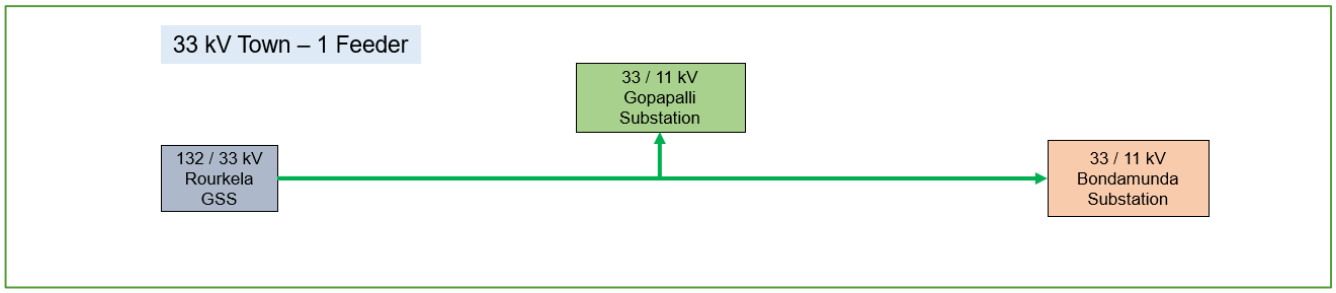
$$Input\ to\ 33kV\ Basanti\ feeder = (Consumption\ of\ 33kV\ Basanti\ feeder + Consumtion\ of\ 33kV\ Town\ 1) - Consumption\ of\ 11kV\ Bondamunda\ feeder$$

The input energy for Basanti 33kV is thus taken as a sum of the individual meter readings.

Feeder Name	Reading on 1st April 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
33 kV Basanti feeder	7,17,909	15,01,286	60	293.46
Feeder Name	Reading on 1st May 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
Town-1(old REC)	89,12,658	90,63,322	120	180.80
Feeder Name	Consumption on 1st May 2018 (Units)	Cumulative consumption till 1st April 2019 (Units)		Input Energy (LU)
11kV Bondamunda feeder	613800	9241200		98.55
Total input energy for 33 kV Basanti feeder (293.46 + 180.80 - 98.55)				**392.01**

It must be noted that the meter readings at 11kV Bonamunda feeder were unavailable. The consumption is calculated from load survey by MRT Rourkela





Billed units of all 11 kV feeders can be summed up as per the list of feeder codes. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV DAV feeder	127.00	-	127.00
11 kV PHD feeder	0.40	15.37	15.76
11 kV MS Palli feeder	133.45	1.48	134.92
Total energy billed for connected consumers of 11 kV feeders			277.69
Total input energy for 33 kV Basanti & Town 1 feeder			392.01
Billing efficiency (%)			**70.84%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV DAV feeder	606.12	-	553.30	-
11 kV PHD feeder	1.87	87.19	1.51	87.19
11 kV MS Palli feeder	622.47	8.80	342.16	8.80
Total		1326.46		992.96

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
Collection efficiency (%)				**74.86%**

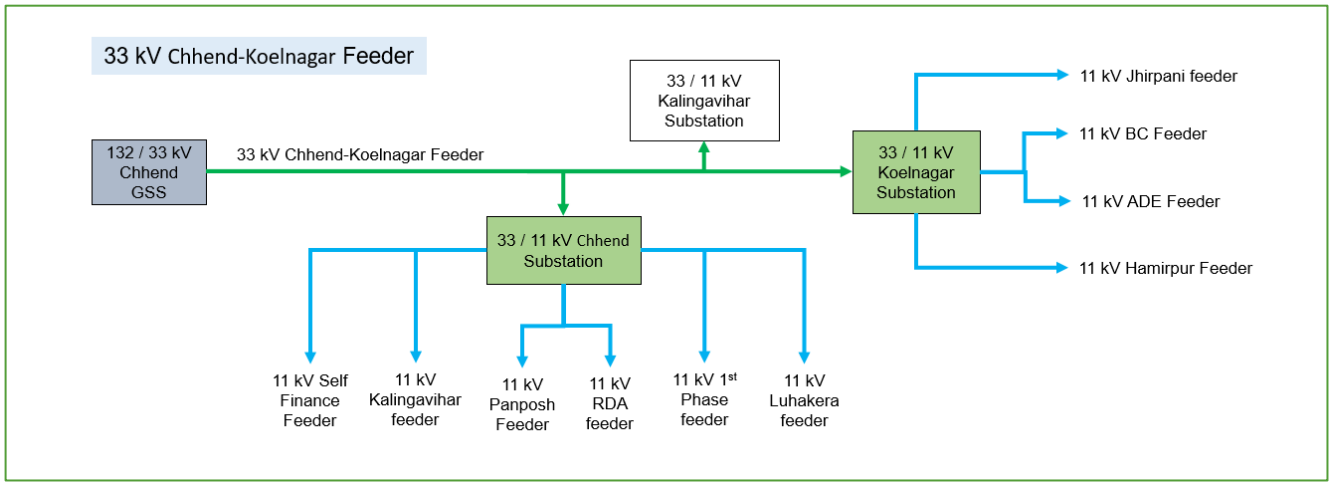
Therefore AT&C loss for 33 kV Basanti & Town – 1 feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	70.84%
Collection efficiency (%)	74.86%
AT&C Loss	**46.97%**

33 kV Chhend-Koelnagar feeder

The input energy recorded for 33 kV Chhend-Koelnagar feeder can be summed up and compared with 11 kV feeders emanating from 33/11 kV Chhend and 33/11 kV Koelnagar substations in order to determine loss on 33 kV line and power transformer loss.

Feeder Name	Reading on 1st April 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
33 kV Chhend-Koelnagar	187,21,100	1,92,90,500	120	683.28
Total input energy for 33 kV Chhend-Koelnagar feeder				**683.28**



Billed units of all 11 kV feeders can be summed up as per the list of feeder codes. Billed units for 11 kV feeders are added from database files and the results are collated below –

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Jhirpani feeder	46.95	5.58	52.53
11 kV BC Block feeder	52.17	0.00	52.17
11 kV ADE Block feeder	79.45	0.00	79.45
11 kV Hamirpur feeder	35.43	0.00	35.43
11 kV Self Finance feeder	60.93	1.43	62.36
11 kV Panposh feeder	55.34	3.21	58.54
11 kV RDA feeder	41.63	2.64	44.27
11 kV Chhend 1st Phase	80.41	0.00	80.41
11 kV Kalinga Vihar	67.88	0.00	67.88
11 kV Luhakera	23.06	5.67	28.73
Total energy billed for connected consumers of 11 kV feeders			561.76
Total input energy for 33 kV Chhend-Koelnagar feeder			683.28
Billing efficiency (%)			**82.22 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Jhirpani feeder	234.25	35.86	189.49	35.86
11 kV BC Block feeder	260.53	-	240.40	-
11 kV ADE Block feeder	415.40	-	387.78	-
11 kV Hamirpur feeder	163.53	-	145.52	-
11 kV Self Finance feeder	307.60	12.73	322.43	12.73
11 kV Panposh feeder	284.98	23.35	262.75	23.35
11 kV RDA feeder	197.18	19.43	206.21	19.43
11 kV Chhend 1st Phase	396.40	-	403.74	-
11 kV Kalinga Vihar	328.35	-	332.86	-
11 kV Luhakera	118.59	24.89	87.28	24.89
Total		2823.05		2694.70
Collection efficiency (%)				**95.45 %**

Therefore AT&C loss for 33 kV Chhend-Koelnagar feeder can be calculated as follows:

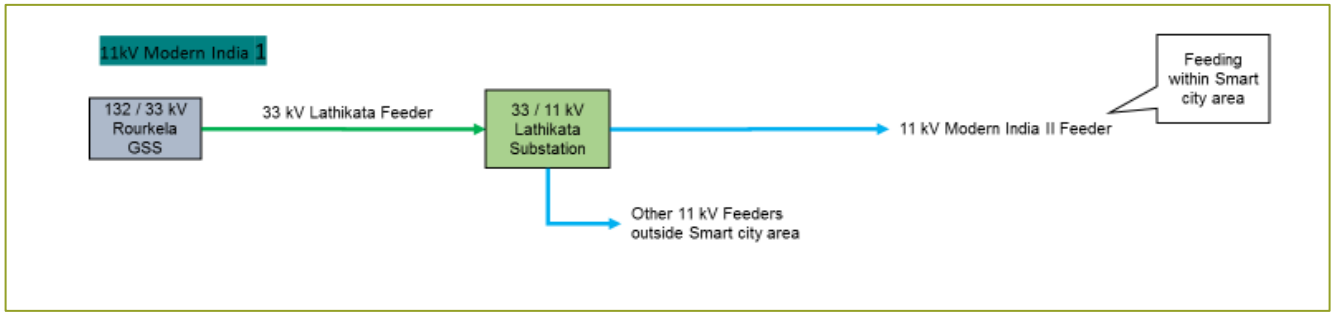
Parameter	Value
Billing efficiency (%)	82.22%
Collection efficiency (%)	95.45%
AT&C Loss	**21.52%**

11 kV Input point feeder-wise losses

11 kV Modern India - 1 feeder

11 kV Modern India – 1 feeder emanates from 33/11 kV Lathikata substation which in turn is supplied power through 33 kV Lathikata feeder from 132/33 kV Rourkela GSS. While other feeders from 33/11 kV Lathikata substation cater to areas outside smart city, 11 kV Modern India – 1 (partially) caters to Rourkela Smart city area. Input energy of the feeder is calculated as follows:
The total transformation capacity installed on the feeder is 8000kVA, out of that around 800kVA of transformation capacity falls under the smart city area. Therefore the input billing and collection is proportioned to be 10% of the total figures of the feeder as whole.

Feeder Name	Input Energy (LU)
11 kV Modern India - I feeder	11.98



Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Modern India - I (AIAA)	9.52	-	9.52
Total input energy for 11 kV Modern India - 1 feeder			11.98
Billing efficiency (%)			**79.47%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Modern India - I (AIAA)	36.36	-	36.05	-
Total		36.36		36.05
Collection efficiency (%)				**99.15%**

Therefore AT&C loss for 11 kV Modern India – 1 feeder can be calculated as follows:

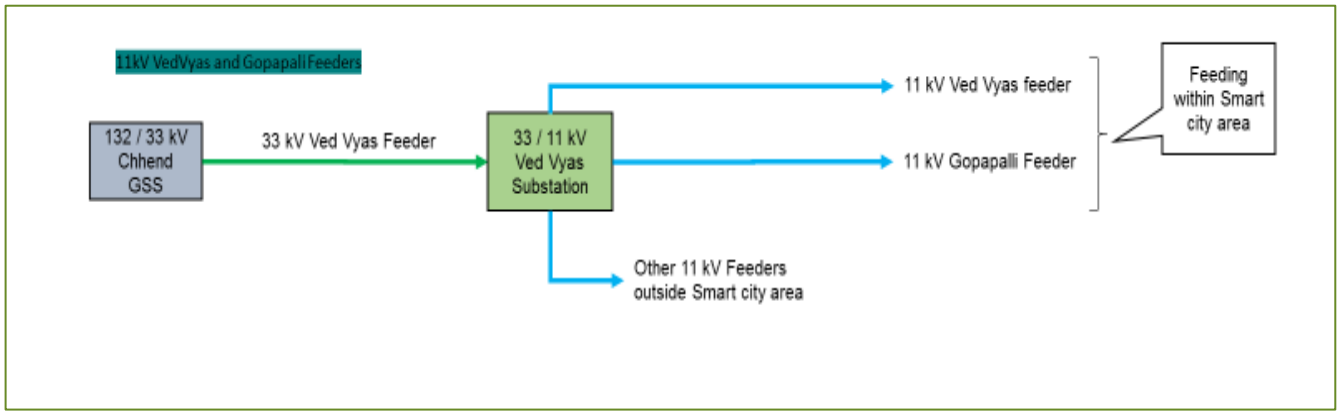
Parameter	Value
Billing efficiency (%)	79.47 %
Collection efficiency (%) (Capped at 100%)	99.15 %
AT&C Loss	**21.21 %**

11 kV Ved Vyas feeder

11 kV Vedvyas feeder emanates from 33/11 kV Vedvyas substation which in turn is supplied power through 33 kV Vedvyas feeder from 132/33 kV Chhend GSS. While other feeders from 33/11 kV Vedvyas substation cater to areas outside smart city, 11 kV Vedvyas and 11 kV Gopapalli feeders caters to Rourkela Smart city area. Input energy of the feeder is calculated as follows:

The Meter for Vedvyas feeder was defective from February Mid and was replaced afterwards. However the readings for the months of March and April could not be recorded and is thus taken on the basis of average consumption of the last 10 months.
Total For 10 Months:103.39 LU
Average per month: 10.34 LU
Consumption for February and March - (2X10.34=20.68)

Feeder Name	Reading on 1st April 2018	Reading on 1st Feb 2019	Multiplying Factor (MF)	Input Energy (LU)
11 kV Vedvyas feeder	5,867.71	6384.66	20000	103.39
Consumption for February and March				20.68
Total input energy for 11 kV Vedvyas feeder				124.07



Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Vedvyas (BDCC)	70.00	26.44	96.44
Total input energy for 11 kV Vedvyas feeder			124.07
Billing efficiency (%)			**77.73 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Vedvyas (BDCC)	508.80	178.93	482.09	178.93
Total		687.73		661.02
Collection efficiency (%)				**96.12 %**

Therefore AT&C loss for 11 kV Vedvyas feeder can be calculated as follows:

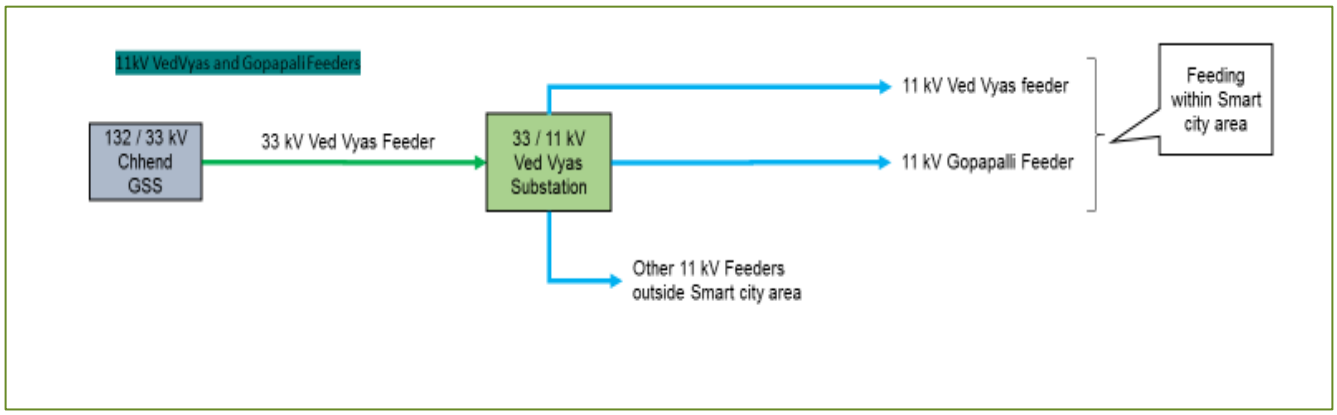
Parameter	Value
Billing efficiency (%)	77.73 %
Collection efficiency (%)	96.12 %
AT&C Loss	**25.29 %**

11 kV Gopapalli feeder

11 kV Gopapalli feeder emanates from 33/11 kV Vedvyas substation which in turn is supplied power through 33 kV Vedvyas feeder from 132/33 kV Chhend GSS. While other feeders from 33/11 kV Vedvyas substation cater to areas outside smart city, 11 kV Vedvyas and 11 kV Gopapalli feeders caters to Rourkela Smart city area. Input energy of the feeder is calculated as follows:

The Meter for Gopapalli feeder was defective from February Mid and was replaced afterwards. However the readings for the months of March and April could not be recorded and is thus taken on the basis of average consumption of the last 10 months.
Total for 10 months: 103.39 LU
Average per month: 10.34 LU
Consumption for February and March - (2X10.34=20.68)

Feeder Name	Reading on 1st April 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
11 kV Gopapalli feeder	11,340.44	11,608.01	20000	53.51
Consumption for February and March				10.70
Total input energy for 11 kV Gopapalli feeder				**64.22**



Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Gopapalli (BDCB)	34.87	7.25	42.12
Total input energy for 11 kV Gopapalli feeder			64.22
Billing efficiency (%)			**65.60 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Gopapalli (BDCB)	211.20	51.77	174.94	51.77
Total		262.97		226.71
Collection efficiency (%)				**86.21 %**

Therefore AT&C loss for 11 kV Gopapalli feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	64.22 %
Collection efficiency (%)	86.21 %
AT&C Loss	**43.45 %**

11 kV Nayabazar feeder

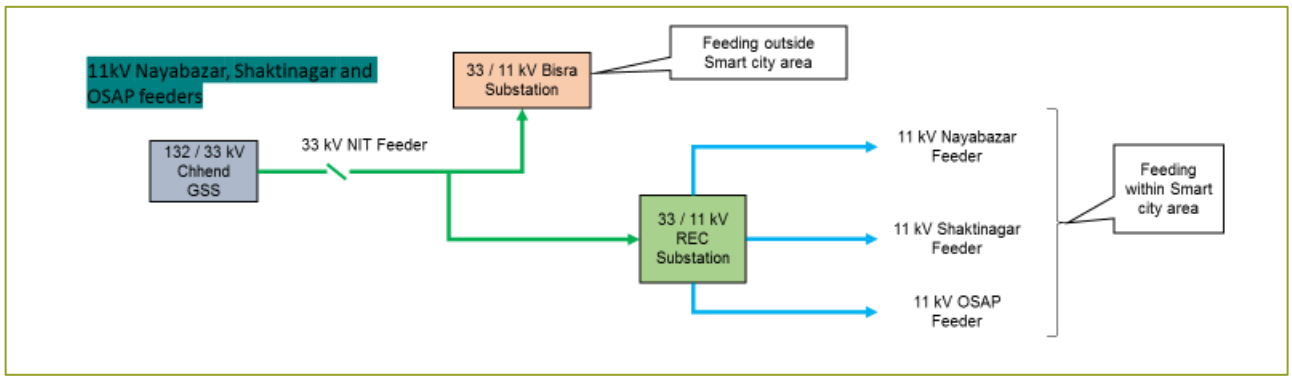
11 kV Nayabazar feeder emanates from 33/11 kV REC substation which in turn is supplied power through 33 kV NIT feeder from 132/33 kV Chhend GSS. All three feeders from 33/11 kV REC substation cater to areas within smart city.
The Meter installed at 11kV Nayabazar feeder was defective from January 2019 onwards. Consumption of these three months is calculated on the basis of average consumption per month derived from meter readings till January 1st 2019.

$$Total\ Input\ till\ january\ 1st = (IMR\ April\ 2018 - FMR\ January\ 2019) * M.F$$
$$Total\ Input\ upto\ January\ 2019 = (63893.19 - 63167.79) \times 4000 = 2893600$$
$$Input\ for\ the\ months\ January, February\ \&\ March = \frac{2893600}{9} \times 3 = 964533$$

From May 2018 11kV Nayabazar feeder started drawing power from 11kV Bondamunda feeder. Input energy of 11 kV Nayabazar feeder is calculated as follows:

$$Input\ energy\ to\ 11kV\ Nayabazar\ feeder = Consumption\ of\ 11kV\ Nayabazar\ Feeder + Consumption\ of\ 11kV\ \ Bondamunda\ Feeder$$

Feeder Name	Reading on 1st April 2018	Reading on 1st January 2019	Multiplying Factor (MF)	Input Energy (LU)
11 kV Nayabazar feeder	63,169.79	63,893.19	4000	28.94
Consumption for the months January February and March				9.65
Consumption of 11kV Bondamunda feeder				98.55
Total input energy for 11 kV Nayabazar feeder				**137.14**



Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Nayabazar (AAAA)	113.95	4.96	118.91
Total input energy for 11 kV Nayabazar feeder			137.14
Billing efficiency (%)			**86.71 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Nayabazar (AAAA)	523.42	25.55	432.75	25.55
Total		548.98		458.31
Collection efficiency (%)				**83.48 %**

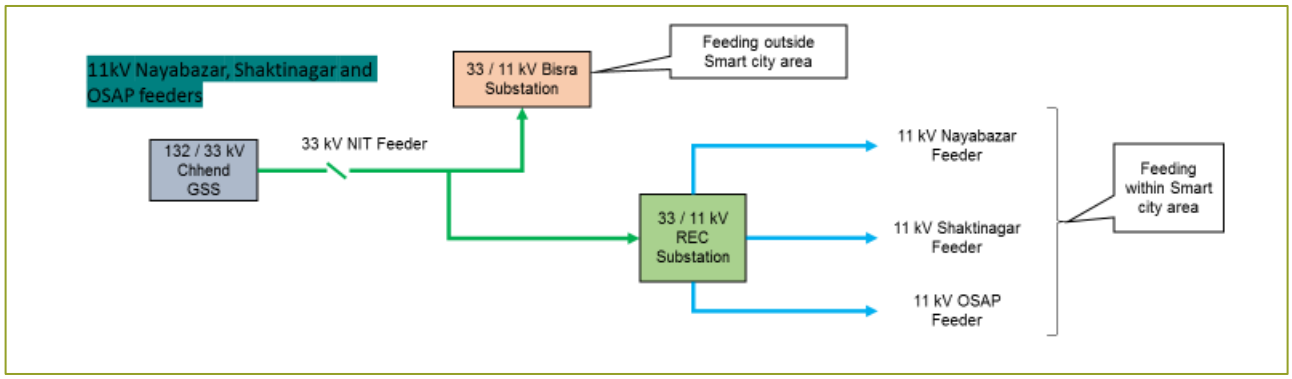
Therefore AT&C loss for 11 kV Nayabazar feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	86.71 %
Collection efficiency (%)	83.48 %
AT&C Loss	**27.61 %**

11 kV OSAP feeder

11 kV OSAP feeder emanates from 33/11 kV REC substation which in turn is supplied power through 33 kV NIT feeder from 132/33 kV Chhend GSS. All three feeders from 33/11 kV REC substation cater to areas within smart city. Input energy of 11 kV OSAP feeder is calculated as follows:

Feeder Name	Reading on 1st April 2018	Reading on 1st April 2019	Multiplying Factor (MF)	Input Energy (LU)
11 kV OSAP feeder	30,920.86	32743.51	6000	109.36
Total input energy for 11 kV OSAP feeder				**109.36**



Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV OSAP (AAAD)	67.78	-	67.78
Total input energy for 11 kV OSAP feeder			109.36
Billing efficiency (%)			**61.98%**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV OSAP (AAAD)	329.40	-	252.71	-
Collection efficiency (%)				**76.72 %**

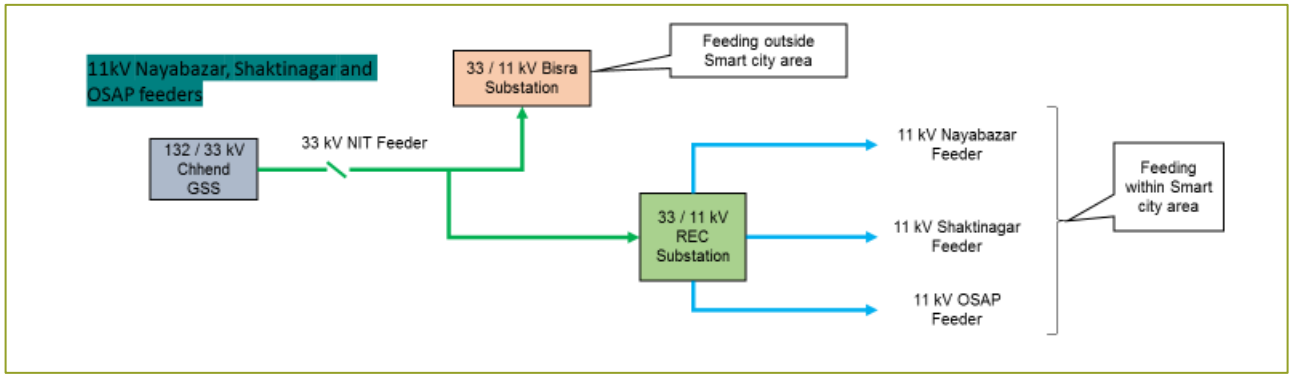
Therefore AT&C loss for 11 kV OSAP feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	61.98 %
Collection efficiency (%)	76.72 %
AT&C Loss	**52.45 %**

11 kV Shaktinagar feeder

11 kV Shaktinagar feeder emanates from 33/11 kV REC substation which in turn is supplied power through 33 kV NIT feeder from 132/33 kV Chhend GSS. All three feeders from 33/11 kV REC substation cater to areas within smart city. Input energy of 11 kV Shaktinagar feeder is calculated as 95.38 LU. It must be noted that the meter at Shaktinagar feeder was defective from December 2017. The input is provided by MRT WESCO Rourkela based on the previous year consumption and load growth:

Feeder Name	Input Energy (LU)
11 kV Shaktinagar	95.38



Billed units for the feeder can be derived by adding up LT billed energy from LT billing database provided by DFMs and HT billed energy from HT billing database provided by MRT division.

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Shaktinagar (AAAB)	77.87	2.47	80.34

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
Total input energy for 11 kV Shaktinagar feeder			95.38
Billing efficiency (%)			**84.23 %**

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Shaktinagr (AAAB)	408.83	16.23	394.99	16.23
Collection efficiency (%)				**96.74 %**

Therefore AT&C loss for 11 kV Shaktinagar feeder can be calculated as follows:

Parameter	Value
Billing efficiency (%)	84.23 %
Collection efficiency (%)	96.74 %
AT&C Loss	**18.51 %**

It may be noted that according to the guidelines Collection efficiency shall be considered not more than 100% while computing AT&C losses.

Total Input energy into the smart city area

Sl. No.	Feeder Name	Input Energy (LU)
1	33 kV Industrial Estate feeder	227.95
2	33 kV Pilot Project feeder	37.45
3	33 kV Old IDC feeder	437.98
4	33 kV Town - 2 feeder	643.37
5	33 kV Basanti feeder	293.46
6	33 kV Town–1 feeder	98.55
7	33 kV Chhend-Koelnagar feeder	683.28

Sl. No.	Feeder Name	Input Energy (LU)
8	11 kV Modern India - I feeder	11.98
9	11 kV Vedvyas feeder	124.07
10	11 kV Gopapalli feeder	64.22
11	11 kV Nayabazar feeder	137.14
12	11 kV OSAP feeder	109.36
13	11 kV Shaktinagar feeder	95.38
Total input energy for Rourkela smart city area (FY 2018-19 till Feb'19)		**2,964.18**

Billed energy booked under the smart city area:

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Pilot Project (Town)	3.33	1.09	4.42
11 kV Industrial Estate feeder	123.56	6.40	129.96
11 kV Town feeder	38.06	15.41	53.47
11 kV PHD feeder	0.42	15.37	15.79
11 kV Raw Water feeder	24.29	32.88	57.17
11 kV College feeder	92.82	29.38	122.20
11 kV Town feeder	161.56	0.00	161.56
11 kV RGH feeder	0.00	0.00	0.00
11 kV Udit Nagar feeder	136.53	20.27	156.80
11 kV Main Road feeder	127.63	67.20	194.83
11 kV Power house road	64.14	0.00	64.14
11 kV Plant Site feeder	118.56	2.22	120.78
11 kV DAV feeder	127.00	0.00	127.00
11 kV PHD feeder	0.40	15.37	15.76
11 kV MS Palli feeder	133.45	1.48	134.92
11 kV Jhirpani feeder	46.95	5.58	52.53
11 kV BC Block feeder	52.17	-	52.17
11 kV ADE Block feeder	79.45	-	79.45

Feeder Name	LT billed energy (LU)	11 kV HT billed energy (LU)	Total billed energy (LU)
11 kV Hamirpur feeder	35.43	-	35.43
11 kV Self Finance feeder	60.93	1.43	62.36
11 kV Panposh feeder	55.34	3.21	58.54
11 kV RDA feeder	41.63	2.64	44.27
11 kV Chhend 1st Phase	80.41	-	80.41
11 kV Kalinga Vihar	67.88	-	67.88
11 kV Luhakera	23.06	5.67	28.73
11 kV Modern India - I (AIAA)	9.52	-	9.52
11 kV Vedvyas (BDCC)	70.00	26.44	96.44
11 kV Gopapalli (BDCB)	34.87	7.25	42.12
11 kV Nayabazar (AAAA)	113.95	4.96	118.91
11 kV OSAP (AAAD)	67.78	-	67.78
11 kV Shaktinagar (AAAB)	77.87	2.47	80.34
Total LT & 11 kV HT	2068.99	266.72	2335.70
Total energy billed for connected consumers of 11 kV feeders			2335.70
Billed energy for 33 kV consumers and DT			60.99
Total billed energy 33 kV consumer + 11 kV feeders			2,396.70
Total input energy			2,964.18
Billing efficiency (%)			**80.86%**

Billed units for HT consumers

Sl. No.	Consumer Name	Billed Energy (LU)
1	Utkal Flour Mills	18.80
2	Project Manager (PMU)	33.47
3	33/0.4 kV Balughat transformer	8.73

Collection booked under the smart city area

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
33 kV Utkal Flour Mill	-	118.92	-	118.92
33 kV Project Manager PMU	-	189.10	-	189.10
33/0.4 kV Balughat (AGLX)	48.98	0.00	56.63	0.00
11 kV Pilot Project (Town)	24.60	6.59	27.09	6.59
11 kV Industrial Estate feeder	710.36	44.22	687.54	44.22
11 kV Town feeder	235.90	106.64	209.02	106.64
11 kV PHD feeder	1.99	87.19	2.24	87.19
11 kV Raw Water feeder	134.35	196.62	128.88	196.62
11 kV College feeder	572.95	199.18	581.54	199.18
11 kV Town feeder	959.25	0.00	974.35	0.00
11 kV RGH feeder	-	-	-	-
11 kV DAV feeder	606.12	-	553.30	-
11 kV PHD feeder	1.87	87.19	1.51	87.19
11 kV MS Palli feeder	622.47	8.80	342.16	8.80
11 kV Jhirpani feeder	234.25	35.86	189.49	35.86
11 kV BC Block feeder	260.53	-	240.40	-
11 kV ADE Block feeder	415.40	-	387.78	-
11 kV Hamirpur feeder	163.53	-	145.52	-
11 kV Self Finance feeder	307.60	12.73	322.43	12.73
11 kV Panposh feeder	284.98	23.35	262.75	23.35
11 kV RDA feeder	197.18	19.43	206.21	19.43
11 kV Chhend 1st Phase	396.40	-	403.74	-
11 kV Kalinga Vihar	328.35	-	332.86	-
11 kV Luhakera	118.59	24.89	87.28	24.89
11 kV Udit Nagar feeder	832.36	125.80	791.79	125.80
11 kV Main Road feeder	785.06	428.58	745.71	428.58
11 kV Power house road	369.39		391.97	
11 kV Plant Site feeder	668.76	17.89	588.25	17.89
11kV Modern India 1	36.36		36.05	
11 kV Vedvyas (BDCC)	508.80	178.93	482.09	178.93
11 kV Gopapalli (BDCB)	211.20	51.77	174.94	51.77

Feeder / Consumer Name	LT billed amount (INR Lacs)	HT billed amount (INR Lacs)	LT collected amount (INR Lacs)	HT collected amount (INR Lacs)
11 kV Nayabazar (AAAA)	523.42	25.55	432.75	25.55
11 kV OSAP (AAAD)	329.40	-	252.71	-
11 kV Shaktinagar	408.83	16.23	394.99	16.23
Total	11299.22	2005.44	10433.96	2005.44
Collection efficiency (%)				**93.50%**

The total AT&C losses, input feeder wise in the Smart City area as a whole under WESCO Rourkela circle for FY 2018-19 is tabulated below:

Sl. No.	Feeder Name	Input Energy (LU)	Billed Units	Billed amount	Collected amount	Billing Efficiency	Collection Efficiency	AT&C Losses
1	33 kV Industrial Estate feeder	227.95	206.66	1247.23	1200.02	77.87%	96.21%	25.08%
2	33 kV Pilot Project feeder	37.45						
3	33 kV Old IDC feeder	437.99	398.92	2389.61	2415.73	91.08%	101.09%	8.92%
4	33 kV Town - 2 feeder	643.37	536.56	3227.84	3089.99	83.40%	95.73%	20.16%
5	33 kV Basanti feeder	293.46	277.69	1326.46	992.96	70.84%	74.86%	46.97%
6	33 kV Town–1 feeder	98.55						
7	33 kV Chhend-Koelnagar feeder	683.28	561.76	2823.05	2694.70	82.22%	95.45%	21.52%
8	11 kV Modern India - I feeder	11.98	9.52	36.36	36.05	79.47%	99.15%	21.21%
9	11 kV Vedvyas feeder	124.07	96.44	687.73	661.02	77.73%	96.12%	25.29%
10	11 kV Gopapalli feeder	64.22	42.12	262.97	226.71	65.60%	86.21%	43.45%
11	11 kV Nayabazar feeder	137.14	118.91	548.98	458.31	86.71%	83.48%	27.61%
12	11 kV OSAP feeder	109.36	67.78	329.40	252.71	61.98%	76.72%	52.45%
13	11 kV Shaktinagar feeder	95.38	80.34	425.05	411.21	84.23%	96.74%	18.51%
Total for Rourkela smart city area (FY 2018-19)		**2,964.18**	**2,396.70**	**13,304.66**	**12,439.40**	**80.86%**	**93.50%**	**24.40%**

Technical loss verification

Calculation of technical losses

Data regarding line length, location of consumers and substations, conductor size, peak load etc. have been obtained from WESCO in order to calculate the technical losses in line.

Load factor of each line can be calculated using the following formula-

$$\text{Load Factor (LF)} = \frac{\text{Average Demand}}{\text{Maximum Demand}} \times 100 \quad (\%)$$

Since the peak load of all feeders can be calculated in Amperes, we can use the same to determine peak power losses. However, for all periods of time, the I^2R losses cannot be at calculated at peak demand. Therefore, Loss Load Factor (LLF) has been introduced to estimate the actual losses on feeder. LLF is calculated as follows –

$$\text{Loss Load Factor (LLF)} = 0.8 \times LF^2 + 0.2 \times LF$$

Now, to calculate the peak I^2R losses, Resistance (R) can be calculated as for each section as -

$$\text{Resistance of line (R)} = 3 \times r \times L$$

where r is the rated resistance of conductor in Ω (ohm) /km and L is the length

Standard resistance of conductors and cables are listed below for reference –

Conductor / Cable type	Conductor / Cable size	Standard AC resistance (Ω /km) at 75◦C [7]	Usage in Rourkela
AAAC Conductor	Rabbit 55 mm^2	0.7230	Max 11 kV feeders
AAAC Conductor	Dog 100 mm^2	0.3955	-
ACSR Conductor	Rabbit 50 mm^2	0.7761	-
ACSR Conductor	Racoon 80 mm^2	0.5216	Max 33 kV feeders
ACSR Conductor	Dog 100 mm^2	0.3924	-
ACSR Conductor	Panther 200 mm^2	0.1706	-
XLPE Underground Cable	185 mm^2	0.2110	-
XLPE Underground Cable	240 mm^2	0.1620	-
XLPE Underground Cable	630 mm^2	0.0600	-
Aerial Bunched Cable	70 mm^2	0.5670	-

[7] As per IS 398 (Part II) & IS 8130

Conductor / Cable type	Conductor / Cable size	Standard AC resistance (Ω /km) at 75◦C [7]	Usage in Rourkela
Aerial Bunched Cable	90 mm^2	0.4100	-

Table 5 - Standard resistance by conductor / cable type

Further, the peak power losses can be calculated for each section as follows –

Peak power losses (P) = I^2R (Watts)

where I is the peak load of feeder in Amperes (A)

Now, the total technical losses of the feeder can be evaluated as summation of section-wise losses follows –

$$\text{Technical loss (T)} = \sum \frac{\text{LLF x P x 24 hours x 365}}{1000} \text{ kWh}$$

Based on the above methodology, voltage level-wise technical losses have been calculated
33 kV feeders

a) 33 kV Basanti feeder

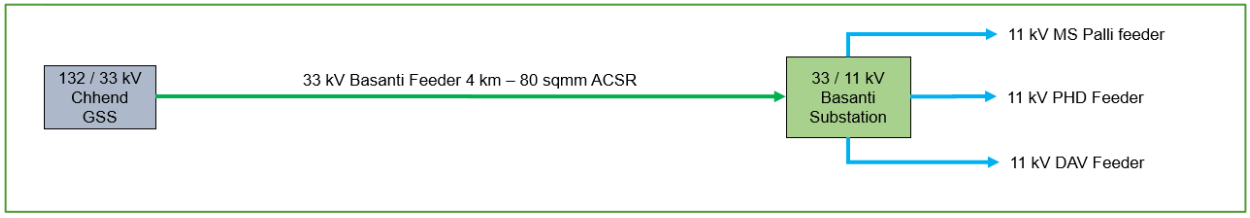


Figure 10 - SLD of 33 kV Basanti feeder

33 / 11 kV Basanti substation has 2 x 8 MVA power transformers with 3 nos. 11 kV feeders catering to Rourkela smart city area. Peak load of the feeder is about 11,920 kVA as per data shared by MRT division. Average power factor is 0.99 as determined from meter data during pf profiling.

Peak load in Amps = 11,920 / (1.732 x 33 x 0.99) = 211 Amp.
I^2R loss = 221^2 x 0.5216 x 3 x 4 km = 278 kW

Energy at peak demand for one year = 11,920 x 365 x 24 x 0.99 = 1033.75 LU
Energy input on feeder during FY 2017-18 = 470.03 LU

Therefore, load factor = 0.45

LLF = 0.8 x 0.45^2 + 0.2 x 0.45 = 0.26

Thus technical loss = 0.26 x 278 x 365 x 24 = 6.24 LU

% technical loss = 1.33 %

a. 33 kV Chhend-Koelnagar Feeder

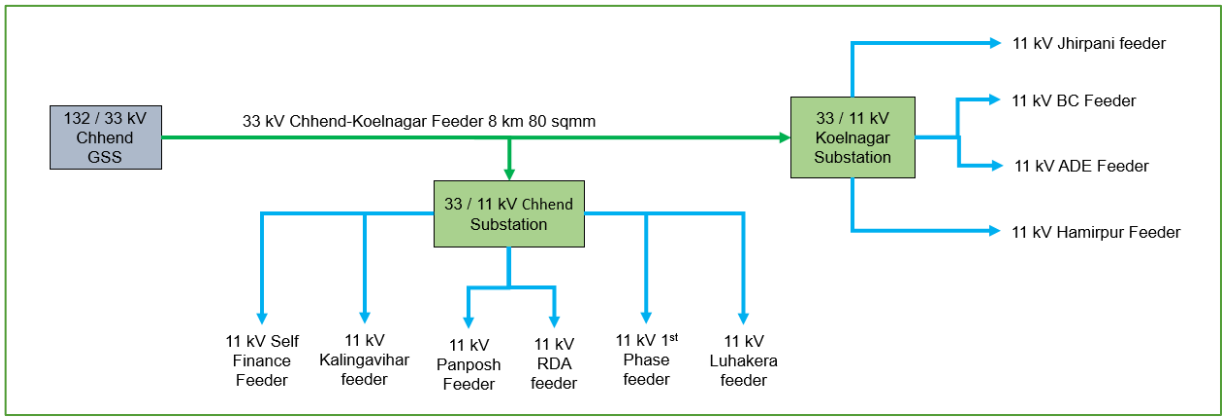


Figure 11 - SLD of 33 kV Chhend - Koelnagar feeder

33 kV Chhend Koelnagar feeder provides supply to 33 / 11 kV Chhend and Koelnagar substations which have 18 MVA and 15 MVA power transformer capacities. There are total 10 nos. 11 kV feeders catering to Rourkela smart city area from these 2 substations. Peak load of the feeder is about 21,480 kVA as per data shared by MRT division. Average power factor is 0.95 as determined from meter data during pf profiling.

Peak load in Amps = 21,480 / (1.732 x 33 x 0.95) = 396 Amp.
I^2R loss = 396^2 x 0.5216 x 3 x 8 km = 1,959 kW

Energy at peak demand for one year = 21,480 x 365 x 24 x 0.95 = 1787.57 LU
Energy input on feeder during FY 2017-18 = 756.62 LU

Therefore, load factor = 0.42

LLF = 0.8 x 0.42^2 + 0.2 x 0.42 = 0.23

Thus technical loss = 0.23 x 1959 x 365 x 24 = 39.12 LU
% technical loss = 5.17 %

b. 33 kV Old IDC (Civil Township feeder)

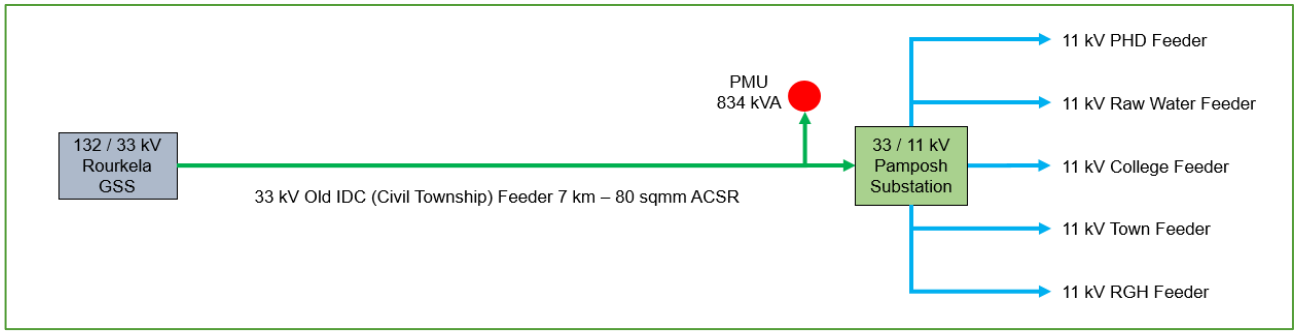


Figure 12 - SLD of 33 kV Old IDC Civil township feeder

33 kV Old IDC (Civil township) feeder provides supply to 33 / 11 kV Pamposh substation which has 2 x 8 = 16 MVA power transformer capacity. There are total 5 nos. 11 kV feeders (out of which 4 are operational at present) catering to Rourkela smart city area. Peak load of the feeder is about 9,200 kVA as per data gathered from substation in-charge (it was not available with MRT department). Average power factor is 0.94 as determined from meter data during pf profiling.

Peak load in Amps = 9,200 / (1.732 x 33 x 0.94) = 171 Amp.
I^2R loss = 171^2 x 0.5216 x 3 x 7 km = 321 kW

Energy at peak demand for one year = 9,200 x 365 x 24 x 0.94 = 757.76 LU
Energy input on feeder during FY 2017-18 = 359.03 LU

Therefore, load factor = 0.47

LLF = 0.8 x 0.47^2 + 0.2 x 0.47 = 0.27

Thus technical loss = 0.27 x 321 x 365 x 24 = 7.72 LU
% technical loss = 2.15 %

c. 33 kV Powerhouse road (Town II) feeder

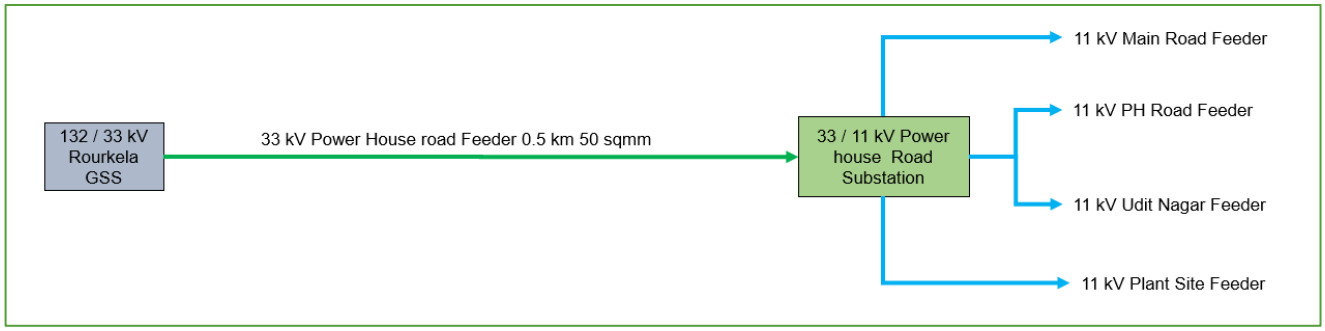


Figure 13 - SLD of 33 kV Powerhouse road (Town II) feeder

33 kV Powerhouse road (Town II) feeder provides supply to 33 / 11 kV Powerhouse road substation which has 1 x 8 + 2 x 5 = 18 MVA power transformer capacity. There are total 4 nos. 11 kV feeders catering to Rourkela smart city area. Peak load of the feeder is about 15,840 kVA as per data gathered from substation in-charge (it was not available with MRT department). Average power factor is 0.96 as determined from meter data during pf profiling.

Peak load in Amps = 15,840 / (1.732 x 33 x 0.96) = 289 Amp.
I^2R loss = 289^2 x 0.5216 x 3 x 0.5 km = 65 kW

Energy at peak demand for one year = 15,840 x 365 x 24 x 0.96 = 1,332.08 LU
Energy input on feeder during FY 2017-18 = 513.37 LU

Therefore, load factor = 0.39

LLF = 0.8 x 0.39^2 + 0.2 x 0.39 = 0.20

Thus technical loss = 0.20 x 65 x 365 x 24 = 1.12 LU
% technical loss = 0.22 %

d. 33 kV Industrial Estate feeder

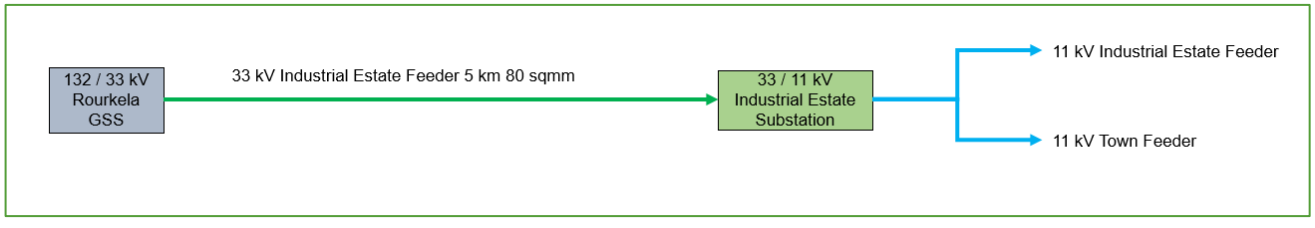


Figure 14 - SLD of 33 kV Industrial Estate feeder

33 kV Industrial estate feeder provides supply to 33 / 11 kV Industrial estate substation which has 1 x 8 MVA power transformer capacity. There are total 2 nos. 11 kV feeders catering to Rourkela smart city area. Peak load of the 33 kV feeder is about 9,990 kVA as per data gathered from substation in-charge (it was not available with MRT department). Average power factor is 0.92 as determined from meter data during pf profiling.

Peak load in Amps = 9,990 / (1.732 x 33 x 0.92) = 190 Amp.
I^2R loss = 190^2 x 0.5216 x 3 x 5 km = 282 kW

Energy at peak demand for one year = 9,990 x 365 x 24 x 0.92 = 805.11 LU
Energy input on feeder during FY 2017-18 = 193.63 LU

Therefore, load factor = 0.24

LLF = 0.8 x 0.24^2 + 0.2 x 0.24 = 0.09

Thus technical loss = 0.09 x 282 x 365 x 24 = 2.33 LU
% technical loss = 1.20 %

e. 33 kV Pilot project feeder

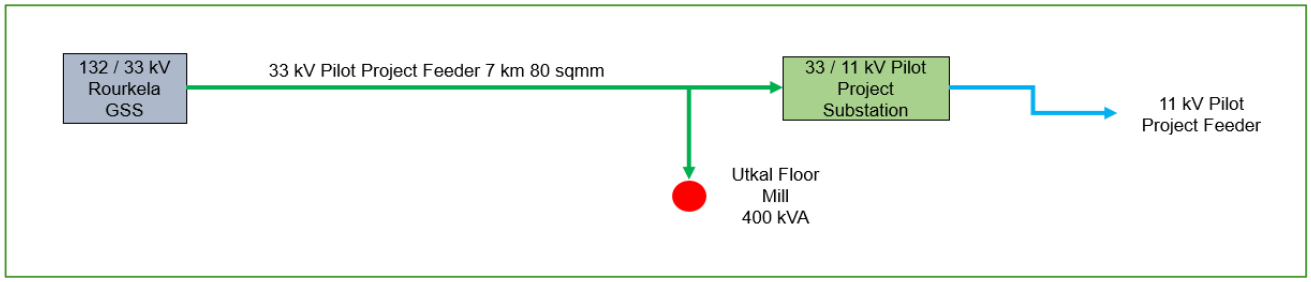


Figure 15 - SLD of 33 kV Pilot project feeder

33 kV Pilot project feeder provides supply to 33 / 11 kV Pilot project substation which has 1.6 MVA power transformer capacity. There is only 1 nos. 11 kV feeder catering to Rourkela smart city area as well as 33 kV consumer "Utkal Floor mill". Peak load of the 33 kV feeder is about 10,800 kVA as per data gathered from substation in-charge (it was not available with MRT department). Average power factor is 0.88 as determined from meter data during pf profiling.

Peak load in Amps = 10,800 / (1.732 x 33 x 0.88) = 215 Amp.
I^2R loss = 215^2 x 0.5216 x 3 x 7 km = 505 kW

Energy at peak demand for one year = 10,800 x 365 x 24 x 0.88 = 832.55 LU
Energy input on feeder during FY 2017-18 = 21.80 LU

Therefore, load factor = 0.03

LLF = 0.8 x 0.03^2 + 0.2 x 0.03 = 0.01

Thus technical loss = 0.01 x 505 x 365 x 24 = 0.26 LU
% technical loss = 1.17 %

Sl. No.	Feeder Name	Input Energy in FY 17-18 (LU)	Technical Loss in LU	% Technical loss
a.	33 kV Basanti feeder	470.03	6.24	1.33%
b.	33 kV Chhend Koelnagar feeder	756.62	39.12	5.17%
c.	33 kV Old IDC (Civil township) feeder	359.03	7.72	2.15%
d.	33 kV Powerhouse road (Town II) feeder	513.37	1.12	0.22%
e.	33 kV Industrial Estate feeder	193.63	2.33	1.20%
f.	33 kV Pilot project feeder	21.80	0.26	1.19%
Overall technical loss at 33 kV		**2,314.48**	**56.79**	**2.45%**

Figure 16 - Summary of Technical losses at 33 kV level

11 kV feeders

Technical loss for 8 nos. sample 11 kV feeders have been evaluated using the same methodology as shared above.

a. 11 kV DAV feeder

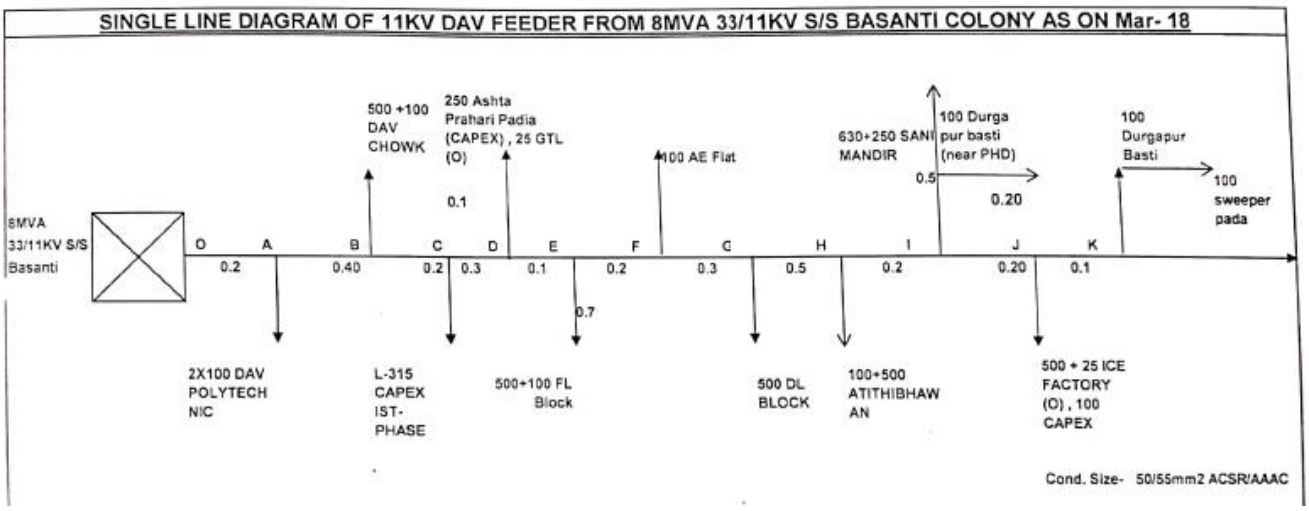


Figure 17 - SLD of 11 kV DAV feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.96 pf	Resistance (Ohms)	I^2R (kW)
J	K	0.10	200	200	10.93	0.22	0.03
I	J	0.20	625	825	45.11	0.43	0.88
I1	I2	0.20	100	300	16.40	0.43	0.12
I	I1	0.50	880	1180	64.51	1.08	4.51
H	I	0.20	0	825	45.11	0.43	0.88
G	H	0.50	600	1425	77.91	1.08	6.58
F	G	0.30	500	1925	105.25	0.65	7.21
E	F	0.20	100	2025	110.71	0.43	5.32
E	E1	0.70	600	2625	143.52	1.52	31.27
D	E	0.10	0	2025	110.71	0.22	2.66
C	D	0.30	275	2300	125.75	0.65	10.29
B	C	0.20	315	2615	142.97	0.43	8.87
A	B	0.40	600	3215	175.77	0.87	26.81
O	A	0.20	200	3415	186.71	0.43	15.12
Total technical loss (kW)							**120.55**

Table 6 - Node-wise technical loss for DAV feeder

Energy at peak demand for one year = 3,415 x 365 x 24 x 0.96 = 287.19 LU
Energy input on feeder during FY 2017-18 = 140.04 LU

Therefore, load factor = 0.49

LLF = $0.8 \times 0.49^2 + 0.2 \times 0.49 = 0.29$

Thus technical loss = 0.29 x 120.55 x 365 x 24 = 3.04 LU
% technical loss = 2.17 %

b. 11 kV BC feeder

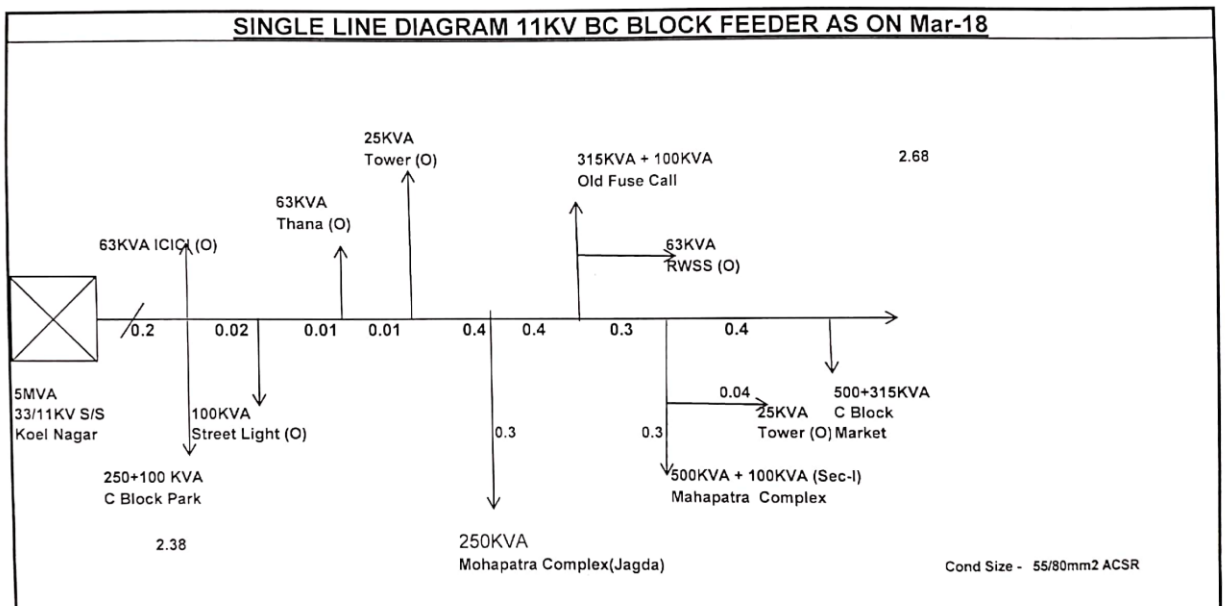


Figure 18 - SLD of 11 kV BC Block feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt Km)	DT Capacity (kVA)	Cumulative DT Capacity (kVA)	Peak current (A) @ 0.95 pf	Resistance (Ohms)	I2R (W)
G	H	0.40	815	815	45.03	0.93	1.89
F	G	0.64	625	1,440	79.56	1.49	9.43
E	F	0.40	478	1,918	105.97	0.93	10.46
D	E	0.70	250	2,168	119.78	1.63	23.38
C	D	0.01	25	2,193	121.16	0.02	0.34
B	C	0.01	63	2,256	124.64	0.02	0.36
A	B	0.02	100	2,356	130.17	0.05	0.79
O	A	0.20	413	2,769	152.98	0.47	10.90
Total technical loss (kW)							**57.55**

Table 7 - Node-wise technical loss for 11 kV BC feeder

Energy at peak demand for one year = 2,769 x 365 x 24 x 0.95 = 230.44 LU
Energy input on feeder during FY 2017-18 = 74.87 LU

Therefore, load factor = 0.32

LLF = 0.8 x 0.32^2 + 0.2 x 0.32 = 0.15

Thus technical loss = 0.15 x 57.55 x 365 x 24 = 0.75 LU
% technical loss = 1.00 %

c. 11 kV Jhirpani feeder

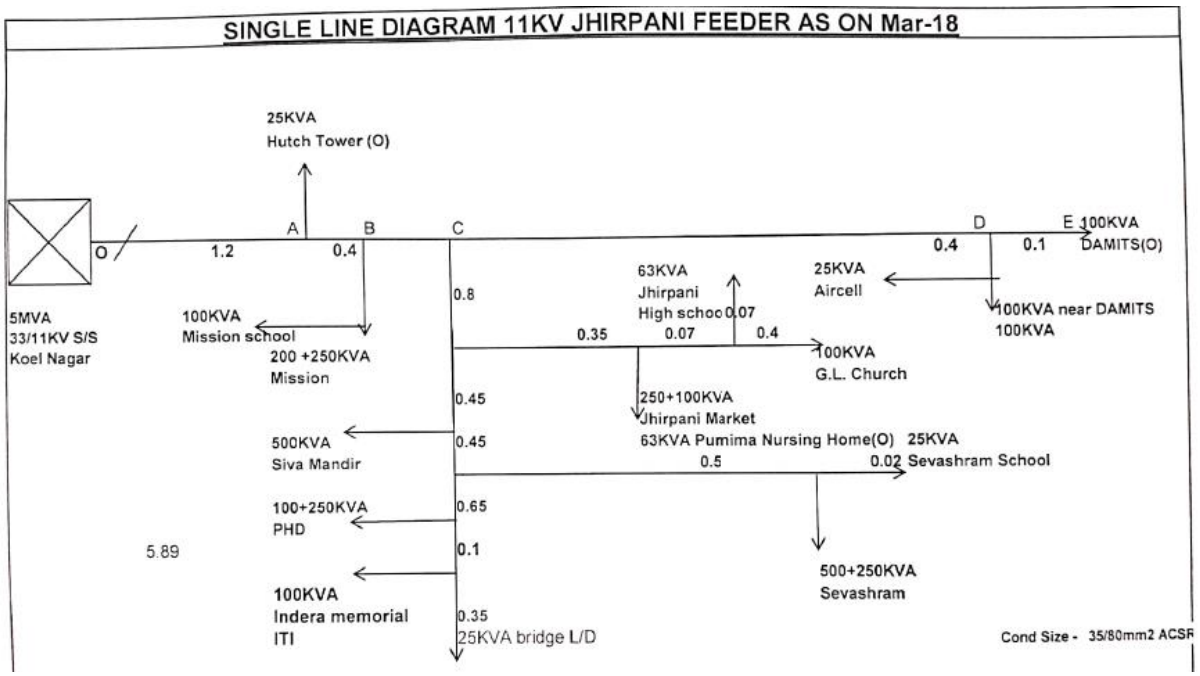


Figure 19 - SLD of 11 kV Jhirpani feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cumulative DT Capacity (kVA)	Peak current (A) @ 0.97 pf	Resistance (Ohms)	I2R (W)
P	Q	0.35	25	200	10.82	0.81	0.10
O	P	0.10	100	300	16.23	0.23	0.06
L	O	0.65	350	650	35.17	1.51	1.87
K	L	0.45	0	650	35.17	1.05	1.30
L	M	0.50	750	1400	75.75	1.16	6.68
M	N	0.02	25	1425	77.11	0.05	0.28
F	K	0.45	500	1925	104.16	1.05	11.37

F	G	0.35	350	2275	123.10	0.81	12.35
G	H	0.07	0	2275	123.10	0.16	2.47
H	I	0.07	63	2338	126.51	0.16	2.61
H	J	0.40	100	2438	131.92	0.93	16.21
C	F	0.80	0	2438	131.92	1.86	32.42
D	E	0.10	100	2538	137.33	0.23	4.39
C	D	0.40	225	2763	149.51	0.93	20.82
B	C	0	0	2763	149.51	-	-
A	B	0.4	550	3313	179.27	0.93	29.93
O	A	1.2	25	3338	180.62	2.79	91.15
Total technical loss (kW)							**233.98**

Table 8 - Node-wise technical loss for 11 kV Jhirpani feeder

Energy at peak demand for one year = 3,338 x 365 x 24 x 0.97 = 283.64 LU
Energy input on feeder during FY 2017-18 = 91.13 LU

Therefore, load factor = 0.32

LLF = $0.8 \times 0.32^2 + 0.2 \times 0.32 = 0.15$

Thus technical loss = 0.15 x 233.98 x 365 x 24 = 3.01 LU
% technical loss = 3.30 %

d. 11 kV Nayabazar

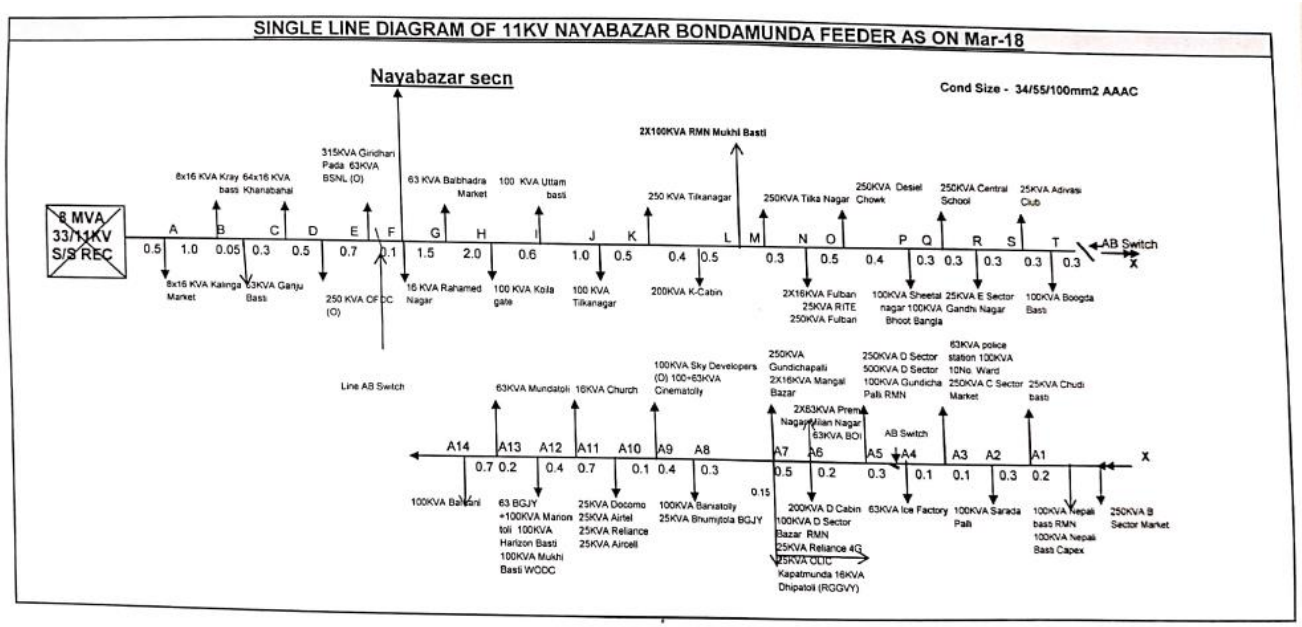


Figure 20 - SLD of 11 kV Nayabazar feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.83 pf	Resistance (Ohms)	I2R (W)
A13	A14	0.70	100	200	12.65	1.63	0.26
A12	A13	0.20	63	263	16.63	0.47	0.13
A11	A12	0.40	363	626	39.59	0.93	1.46
A10	A11	0.70	16	642	40.60	1.63	2.69
A9	A10	0.10	100	742	46.92	0.23	0.51
A8	A9	0.40	263	1005	63.55	0.93	3.76
A7	A8	0.30	125	1130	71.46	0.70	3.57
A7	A71	0.15	50	1462	92.45	0.35	2.99
A6	A7	0.50	282	1412	89.29	1.16	9.28
A5	A6	0.20	489	1951	123.37	0.47	7.09
A4	A5	0.30	850	2801	177.13	0.70	21.91
A3	A4	0.10	63	2864	181.11	0.23	7.64

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.83 pf	Resistance (Ohms)	I2R (W)
A2	A3	0.10	413	3277	207.23	0.23	10.00
A1	A2	0.30	100	3377	213.55	0.70	31.85
X	A1	0.2	25	3402	215.13	0.47	21.55
T	X	0.3	250	3652	230.94	0.70	37.25
S	T	0.3	100	3752	237.26	0.70	39.32
R	S	0.3	25	3777	238.84	0.70	39.85
Q	R	0.3	25	3802	240.43	0.70	40.38
P	Q	0.3	250	4052	256.23	0.70	45.86
O	P	0.4	200	4252	268.88	0.93	67.33
N	O	0.5	250	4502	284.69	1.16	94.35
M	N	0.3	307	4809	304.10	0.70	64.60
L	M	0	250	5059	319.91	-	-
K1	L	0.5	200	5259	332.56	1.16	128.75
K	K1	0.4	200	5459	345.21	0.93	110.98
J	K	0.5	250	5709	361.02	1.16	151.73
I	J	1	100	5809	367.34	2.33	314.18
H	I	0.6	100	5909	373.67	1.40	195.05
G	H	2	100	6009	379.99	4.66	672.37
F	G	1.5	63	6072	383.97	3.49	514.91
E	F	0.1	16	6088	384.98	0.23	34.51
D	E	0.7	315	6403	404.90	1.63	267.20
C	D	0.5	250	6653	420.71	1.16	206.05
B1	C	0.3	1024	7677	485.47	0.70	164.62
B1	B1	0.05	63	7740	489.45	0.12	27.89
A	B	1	128	7868	497.55	2.33	576.37
O	A	0.5	128	7996	505.64	1.16	297.64
Total technical loss (kW)							**4,215.89**

Table 9 - Node-wise technical loss for 11 kV Nayabazar feeder

Energy at peak demand for one year = 7,996 x 365 x 24 x 0.83 = 581.37 LU
Energy input on feeder during FY 2017-18 = 147.30 LU

Therefore, load factor = 0.25

LLF = $0.8 \times 0.25^2 + 0.2 \times 0.25 = 0.10$

Thus technical loss = 0.10 x 4215.89 x 365 x 24 = 37.38 LU
% technical loss = 25.38 %

e. 11 kV Plant Site feeder

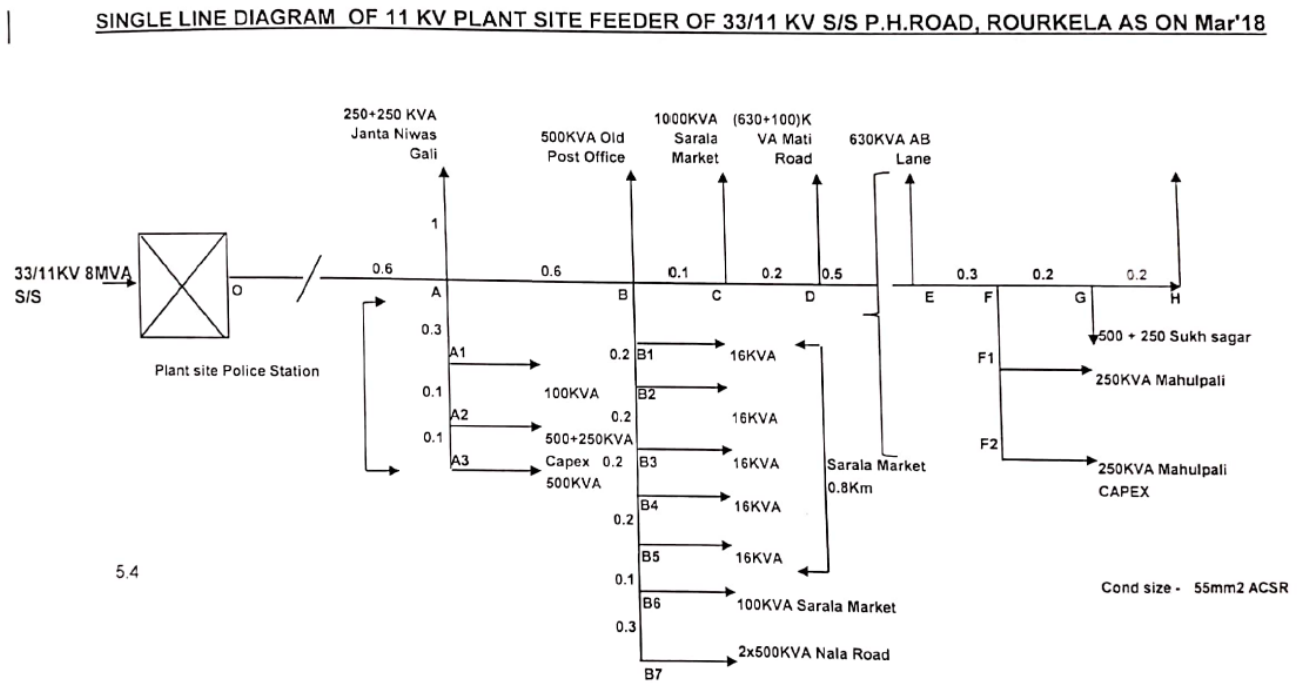


Figure 21 - SLD of 11 kV Plant site road feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.98 pf	Resistance (Ohms)	I2R (W)
G	H	0.20	0	0	-	0.47	-
F	G	0.20	750	750	40.17	0.47	0.75
E	F	0.30	500	1250	66.95	0.70	3.13
D	E	0.50	630	1880	100.69	1.16	11.80
C	D	0.20	730	2610	139.79	0.47	9.10
B	C	0.10	1000	3610	193.34	0.23	8.70
B6	B7	0.30	1000	4610	246.90	0.70	42.58
B5	B6	0.10	100	4710	252.26	0.23	14.82
B4	B5	0.20	16	4726	253.11	0.47	29.83
B3	B4	0.20	16	4742	253.97	0.47	30.04

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.98 pf	Resistance (Ohms)	I2R (W)
B2	B3	0.20	16	4758	254.83	0.47	30.24
B1	B2	0.20	16	4774	255.68	0.47	30.44
B	B1	-	0	4774	255.68	-	-
A	B	0.60	516	5290	283.32	1.40	112.14
A2	0.1	0.1	500	5790	310.10	0.23	22.39
A1	A2	0.1	750	6540	350.27	0.23	28.57
A	A1	0.3	100	6640	355.62	0.70	88.34
A1	A	1	450	7090	379.72	2.33	335.72
O	A	0.6	0	7090	379.72	1.40	201.43
Total technical loss (kW)							**1,000.00**

Table 10 - Node-wise technical loss for 11 kV Plant site feeder

Energy at peak demand for one year = 7,090 x 365 x 24 x 0.98 = 608.66 LU
Energy input on feeder during FY 2017-18 = 237.57 LU

Therefore, load factor = 0.39

LLF = $0.8 \times 0.39^2 + 0.2 \times 0.39 = 0.20$

Thus technical loss = 0.20 x 1000.00 x 365 x 24 = 17.52 LU
% technical loss = 7.37 %

f. 11 kV ADE feeder

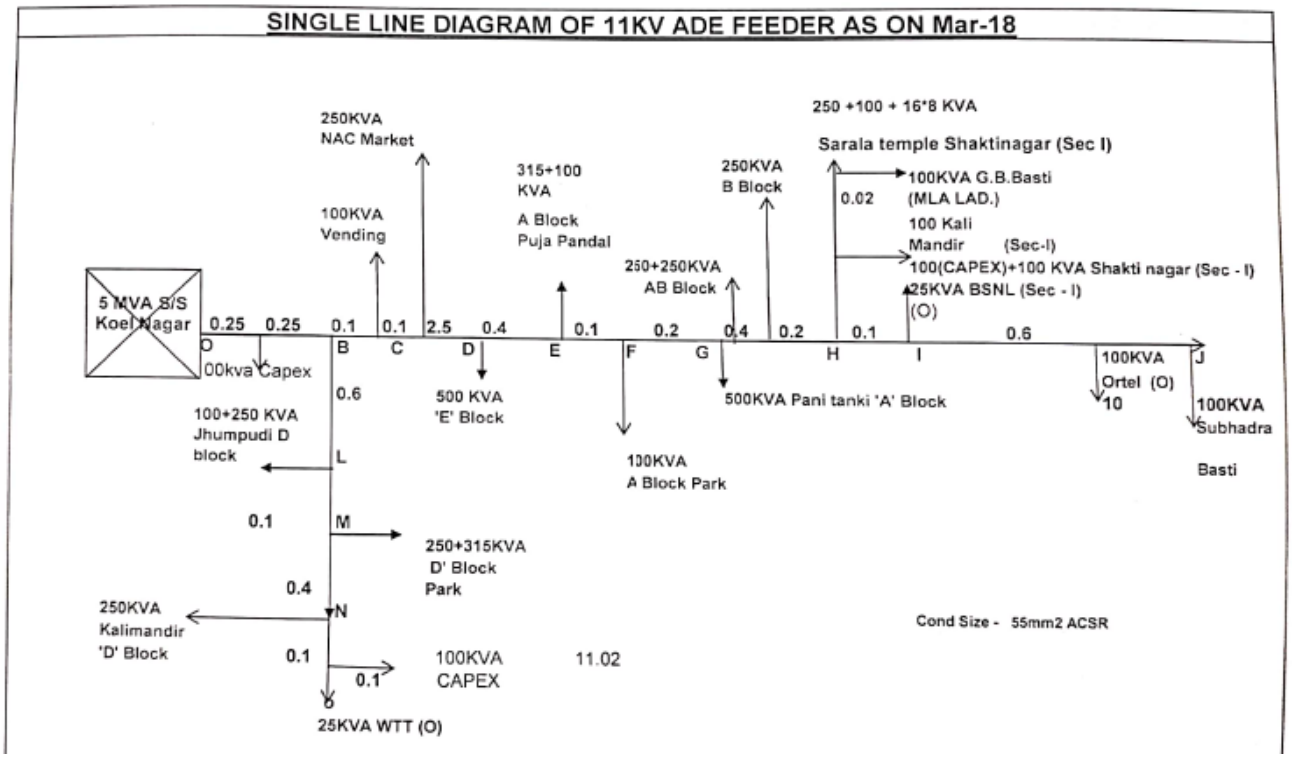


Figure 22 - SLD of 11 kV ADE feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cumulative DT Capacity (kVA)	Peak current (A) @ 0.96 pf	Resistance (Ohms)	I2R (W)
I	J	0.60	200	200	10.93	1.40	0.17
H	I	0.10	25	225	12.30	0.23	0.04
H1	H	0.02	878	1103	60.30	0.05	0.17
G2	H	0.20	0	1103	60.30	0.47	1.69
G1	G2	-	250	1353	73.97	-	-
G	G1	0.40	500	1853	101.31	0.93	9.56
F	G	0.20	500	2353	128.65	0.47	7.71
E	F	0.10	100	2453	134.11	0.23	4.19
D	E	0.40	415	2868	156.80	0.93	22.90

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cumulative DT Capacity (kVA)	Peak current (A) @ 0.96 pf	Resistance (Ohms)	I2R (W)
C1	D	2.50	500	3368	184.14	5.82	197.37
C	C1	0.10	250	3618	197.81	0.23	9.11
B	B1	0.10	100	3718	203.28	0.23	9.62
N1	N2	0.10	100	3818	208.74	0.23	10.15
N	N1	0.10	25	3843	210.11	0.23	10.28
M	N	0.40	250	4093	223.78	0.93	46.64
L	M	0.10	565	4658	254.67	0.23	15.10
B	L	0.60	350	5008	273.80	1.40	104.73
A	B	0.25	0	5008	273.80	0.58	43.64
O	A	0.25	100	5108	279.27	0.58	45.40
Total technical loss (kW)							**538.44**

Table 11 - Node-wise technical loss for 11 kV ADE feeder

Energy at peak demand for one year = 5,108 x 365 x 24 x 0.96 = 429.56 LU
Energy input on feeder during FY 2017-18 = 97.69 LU

Therefore, load factor = 0.23

LLF = $0.8 \times 0.23^2 + 0.2 \times 0.23 = 0.09$

Thus technical loss = 0.09 x 538.44 x 365 x 24 = 4.10 LU
% technical loss = 4.20 %

g. 11 kV Shaktinagar (Jagda) feeder

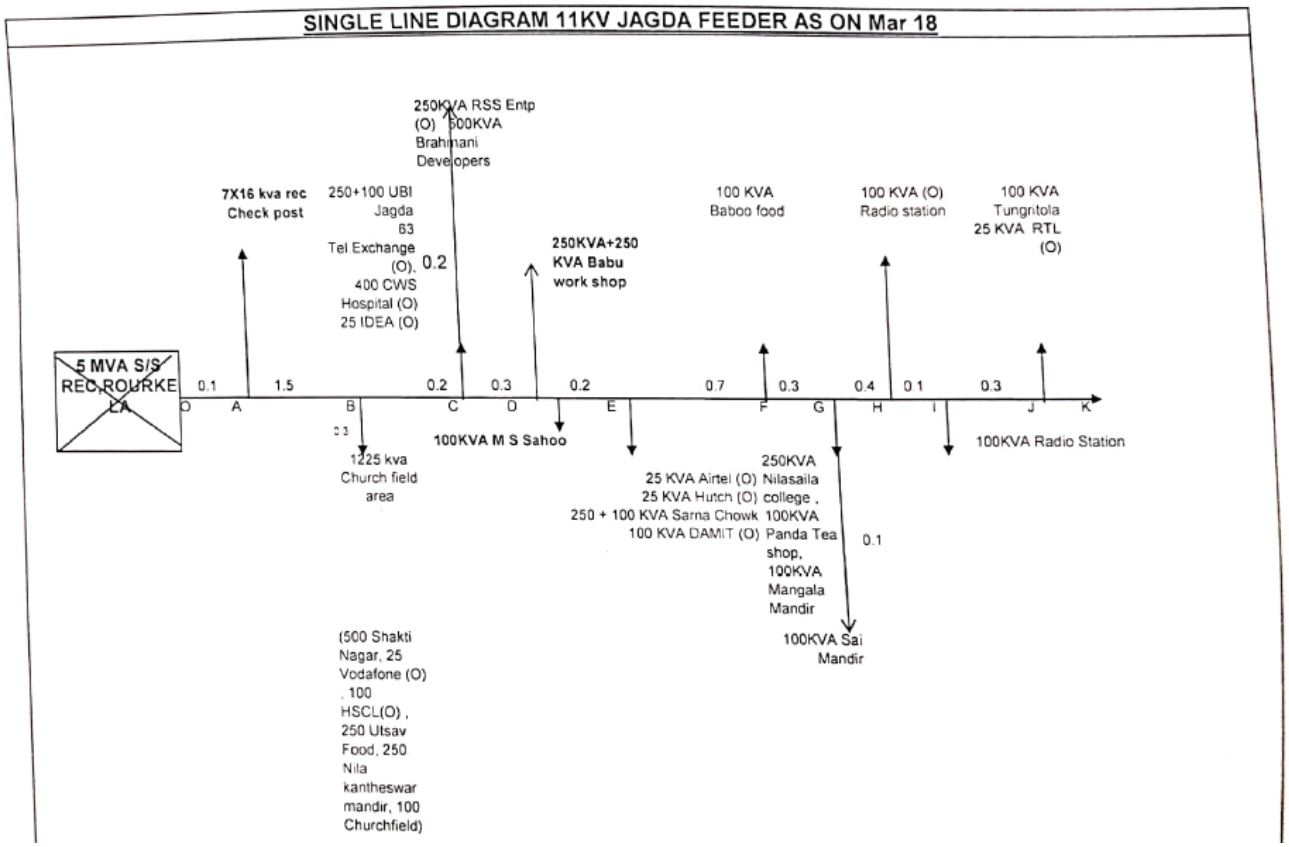


Figure 23 - SLD of 11 kV Shaktinagar (Jagda) feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.98 pf	Resistance (Ohms)	I^2R (kW)
I	J	0.30	125		-	0.70	-
H	I	0.10	100	100	5.36	0.23	0.01
G	H	0.40	100	200	10.71	0.93	0.11
G	G1	0.10	100	200	10.71	0.23	0.03
F	G	0.30	0	200	10.71	0.70	0.08
E	F	0.70	100	300	16.07	1.63	0.42
D	E	0.20	500	800	42.85	0.47	0.85
C	C1	0.20	750	1550	83.01	0.47	3.21

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.98 pf	Resistance (Ohms)	I^2R (kW)
C	D	0.30	600	1400	74.98	0.70	3.93
B	C	0.20	0	1400	74.98	0.47	2.62
A	B	1.50	1225	2625	140.59	3.49	69.03
O	A	0.10	112	2737	146.59	0.23	5.00
Total technical loss (kW)							**85.28**

Table 12 - Node-wise technical loss for 11 kV Shaktinagar feeder

Energy at peak demand for one year = 2,737 x 365 x 24 x 0.98 = 234.97 LU
Energy input on feeder during FY 2017-18 = 40.38 LU

Therefore, load factor = 0.17

LLF = $0.8 \times 0.17^2 + 0.2 \times 0.17 = 0.06$

Thus technical loss = 0.06 x 85.28 x 365 x 24 = 0.43 LU
% technical loss = 1.06 %

h. 11 kV Power house road feeder

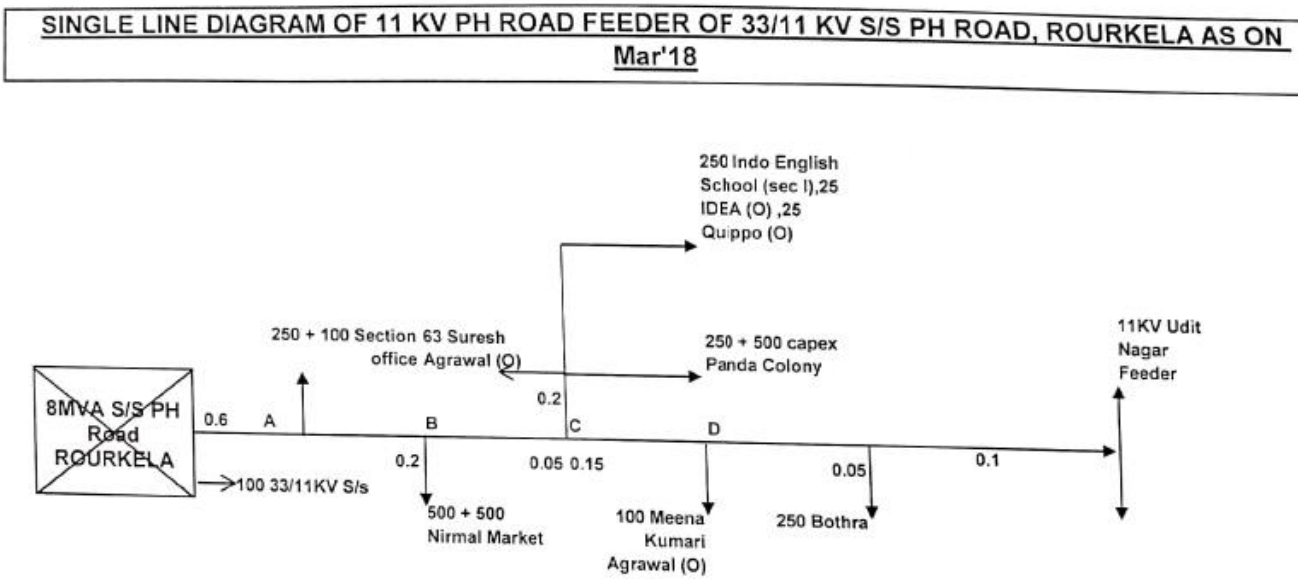


Figure 24 - SLD of 11 kV PH road feeder

For each node in the 11 kV network, the technical loss per node is derived as follows:

Start	End	Length (Ckt km)	DT Capacity (kVA)	Cummulative DT Capacity (kVA)	Peak current (A) @ 0.99 pf	Resistance (Ohms)	I^2R (kW)
E	F	0.10	0	0	-	0.22	-
D	E	0.05	250	250	13.25	0.11	0.02
C	D	0.15	100	350	18.56	0.33	0.11
C	C1	0.20	1400	1650	87.48	0.43	3.32
B	C	0.05	0	350	18.56	0.11	0.04
A	B	0.20	1000	1350	71.57	0.43	2.22
O	A	0.60	350	1700	90.13	1.30	10.57
Total technical loss (kW)							**16.28**

Table 13 - Node-wise technical loss for 11 kV PH road feeder

Energy at peak demand for one year = 1,700 x 365 x 24 x 0.99 = 147.43 LU
Energy input on feeder during FY 2017-18 = 85.28 LU

Therefore, load factor = 0.40

LLF = $0.8 \times 0.40^2 + 0.2 \times 0.40 = 0.21$

Thus technical loss = 0.21 x 16.28 x 365 x 24 = 0.30 LU
% technical loss = 0.51 %

SUMMARY OF TECHNICAL LOSS FOR SAMPLE FEEDERS

Sl. No.	Feeder Name	Input Energy in FY 17-18 (LU)	Technical Loss in LU	% technical loss
a.	11 kV DAV feeder	140.04	3.04	2.17%
b.	11 kV BC feeder	74.87	0.75	1.00%
c.	11 kV Jhirpani feeder	91.13	3.01	3.30%
d.	11 kV Nayabazar	147.30	37.38	25.38%
e.	11 kV Plant Site road	237.57	17.52	7.37%
f.	11 kV ADE feeder	97.69	4.10	4.20%

Sl. No.	Feeder Name	Input Energy in FY 17-18 (LU)	Technical Loss in LU	% technical loss
g.	11 kV Shaktinagar feeder	40.38	0.43	1.06%
h.	11 kV Power house feeder	59.36	0.30	0.51%
Total tech. loss at 11 kV level		**888.35**	**6.53**	**7.49%**

Table 14 - Summary of technical loss for sample 11 kV feeders

T&D loss for sample Distribution transformers

Sl. No.	DT Name	Input Energy (kWh)	Sold Energy (kWh)	% Loss
a.	DTR-1 DAV Polytech	8,699	8,285	4.76
b.	DTR-2 DAV Polytech	28,000	23,847	14.83
c.	DTR-3 DAV Chowk	81,223	51,514	36.57
d.	DTR-5 L-Block DAV	42,878	35,762	16.60
e.	DTR-7 Astaprahi Padia	25,838	22,803	11.75
f.	DTR-10 FL-Block DAV	6,012	5,123	14.79
g.	DTR-12 Atithibhavan	19.874	16,954	14.69

Table 15 - T&D loss for sample Distribution transformers

System Reliability Indices

Interruption data collected from 11 kV feeder meters is as follows:

Sub-Station Name	Feeder Name	11 kV Feeders Meter No.	Duration of interruption (in mins)	Frequency of interruption (Nos.)	No. of Consumers
REC	OSAP	WSC07704	2920	49	3774
	Nayabazar	WSC07685	1251	21	6584
INDUSTRIAL ESTATE	Industrial Estate	ORBS4890	13646	227	3353
PANPOSH	Raw Water	UPB54732	4856	81	1357
	College	UPB54737	5513	92	2868
	Town	ORBS4751	6848	114	3529
	Modern India-II	WSC07576	11635	194	7643
POWER HOUSE	Main Road	WSC32919	13404	223	3255
	Ph. House Road	WES48743	10320	172	1626
	Udit Nagar	WES48745	12000	200	3069
CHEND	Self Finance	WSC39167	2627	44	2203
	Panposh	ORBS4894	8513	142	2572
	RDA	ORBS4763	8517	142	1925
	Chend PH-I	ORBS4777	13877	231	4023
	Kalingavihar	WSC39176	4406	73	2931
BASANTI	Madhusudanpali	ORBS4756	5594	93	5042
	PHD (Basanti-2)	WSC32995	5983	100	2267
	Basanti-I	WES50444	6000	100	5006
KOELNAGAR	Jhirpani	WES48823	6000	100	2259
	ADE Block	WSC07569 OSE00370	6008	100	3186
	Hamirpur	WSC39113 OSE00958	3753.75	63	1928
VEDVYAS	Gopapali	WSC02440	11523	192	128
	vedvyas	WSC13195	6196	103	555

Table 16 - Intteruption of supply -data from feeder metering system

SAIFI (System Average Interruption Frequency Index)

The System Average Interruption Frequency Index (SAIFI) is commonly used as a reliability indicator by electric power utilities. SAIFI is the average number of interruptions that a customer would experience over a period of time. It is calculated as-

$$\text{SAIFI} = \frac{\text{Total number of consumer interruptions}}{\text{Number of consumers served}} \quad \text{(in Numbers)}$$

SAIFI is measured in units of interruptions per consumer. It is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.10 interruptions per consumer.

Sum-product for no. of interruptions and no. of consumers has been taken and overall SAIFI has been calculated as 123.61.

SAIDI (System Average Interruption Duration Index)

The System Average Interruption Duration Index (SAIDI) is commonly used as a reliability indicator by electric power utilities. SAIDI is the average outage duration for each consumer served over a fixed period of time. It is calculated as-

$$\text{SAIDI} = \frac{\text{Sum of all consumer interruption}}{\text{Number of customers served}} \quad \text{(in Hours)}$$

SAIDI is measured in units of time, often minutes or hours. It is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.50 mins.

Sum-product for duration of interruptions and no. of consumers has been taken and overall SAIDI has been calculated as 7416 mins.

Power Quality

Voltage profile

33 KV FEEDERS

Name of 132/33KV GSS	Name of Feeder	Voltage Level	AVG Voltage	V1	V2	V3
Rourkela GSS	33 kV Industrial Estate	33 kV	33,560	33,519	NA	33,600
Rourkela GSS	33 kV Pilot Project	33 kV	33,660	33,468	NA	33,852
Rourkela GSS	33 kV Powerhouse feeder	33 kV	33,963	33,783	NA	34,143
Chhend GSS	33 kV Basanti feeder	33 kV	33,546	33,627	NA	33,465
Chhend GSS	33 kV Chhend – Koelnagar	33 kV	33,567	33,624	NA	33,510

Table 17 - Voltage profile of 33 kV feeders

11 KV FEEDERS

Name of 33/11KV S/S	Nme of 11KV Feeder	Voltage	AVG Voltage	V1	V2	V3
PH Road	Udit Nagar	11KV	10,777	10,749	10,771	10,811
PH Road	Main Road	11KV	11,067	11,080	11,042	11,080
PH Road	Power House Road	11KV	11,039	11,093	10,950	11,074
PH Road	Plant Site Road	11KV	11,151	11,259	11,213	10,982
Basanti	DAV	11KV	11,086	11,081	11,131	11,046
Basanti	PHD	11KV	10,902	10,991	10,842	10,872
Basanti	MS Palli	11KV	11,101	11,085	11,090	11,128
REC	Jagda/Shaktinagar	11KV	10,923	10,920	10,919	10,931
REC	Nayabazar Bondamunda	11KV	10,846	10,849	NA	10,842
REC	OSAP	11KV	10,791	10,788	NA	10,794
Koel Nagar	Jhirpani	11KV	10,794	10,762	10,866	10,753
Koel Nagar	BC	11KV	10,889	10,882	NA	10,896

Name of 33/11KV S/S	Nme of 11KV Feeder	Voltage	AVG Voltage	V1	V2	V3
Koel Nagar	ADE	11KV	10,956	10,958	NA	10,954
Koel Nagar	Hamirpur	11KV	10,935	10,955	10,945	10,904
Chhend	Self Finance	11KV	10,959	10,904	10,968	11,005
Chhend	Panposh	11KV	10,896	10,889	10,879	10,920
Chhend	RDA	11KV	10,937	10,941	10,919	10,951
Chhend	Chend1st Phase	11KV	10,383	10,394	10,369	10,387
Chhend	Kalingavihar	11KV	10,959	10,904	10,968	11,005
Panposh	PHD	11KV	11,138	11,144	11,132	11,140
Panposh	Balughat/RAW WATER	11KV	11,017	11,073	11,014	10,965
Panposh	College	11KV	11,328	11,255	11,336	11,395
Panposh	Town	11KV	11,316	11,310	11,296	11,341
Panposh	RGH	11KV	11,303	11,338	11,283	11,289
Pilot Project	Pilot Project	11KV	11,424	11,450	11,436	11,386
Industrial Estate	Industrial Estate	11KV	10,453	10,456	10,446	10,456
Industrial Estate	Town	11KV	11,086	11,058	NA	11,113
Lathikata	Morden India-II	11KV	10,876	10,875	NA	10,876
Vedvyas	Vedvyas	11KV	10,997	11,065	NA	10,929
Vedvyas	Gopapali	11KV	10,864	10,864	NA	10,864

Table 18 - Voltage profile of 11 kV feeders

Power Factor profile

33 KV FEEDERS

Name of 132/33KV GSS	Name of Feeder	Voltage Level	AVG PF
Rourkela GSS	33 kV Industrial Estate feeder	33KV	0.92
Rourkela GSS	33 kV Pilot project feeder	33KV	0.88
Rourkela GSS	33 kV Old IDC feeder	33KV	0.94
Rourkela GSS	33 kV Powerhouse	33KV	0.96
Chhend GSS	33 kV Basanti feeder	33KV	0.99
Chhend GSS	33 kV Chhend Koelnagar	33KV	0.95

Table 19 - Power factor profile of 33 kV feeders

11 KV FEEDERS

Name of 33/11KV S/S	Nme of 11KV Feeder	Voltage	AVG PF
Power House Road	11 kV Udit Nagar feeder	11KV	0.89
Power House Road	11 kV Main Road feeder	11KV	0.92
Power House Road	11 kV Power House Road feeder	11KV	0.99
Power House Road	11 kV Plant Site Road feeder	11KV	0.98
Basanti	11 kV DAV feeder	11KV	0.96
Basanti	11 kV PHD feeder	11KV	0.99
Basanti	11 kV MS Palli feeder	11KV	0.84
REC	11 kV Jagda/Shaktinagar	11KV	0.98
REC	11 kV Nayabazar Bondamunda	11KV	0.83
REC	11 kV OSAP feeder	11KV	0.94
Koel Nagar	11 kV Jhirpani feeder	11KV	0.97
Koel Nagar	11 kV BC feeder	11KV	0.95
Koel Nagar	11 kV ADE feeder	11KV	0.96

Name of 33/11KV S/S	Nme of 11KV Feeder	Voltage	AVG PF
Koel Nagar	11 kV Hamirpur feeder	11KV	0.99
Chhend	11 kV Self Finance feeder	11KV	0.94
Chhend	11 kV Panposh feeder	11KV	0.91
Chhend	11 kV RDA feeder	11KV	0.89
Chhend	11 kV Chend1st Phase feeder	11KV	0.83
Chhend	11 kV Kalingavihar feeder	11KV	0.87
Chhend	11 kV Luhakera feeder	11KV	0.97
Panposh	11 kV PHD feeder	11KV	0.90
Panposh	11 kV Raw water feeder	11KV	0.63
Panposh	11 kV College feeder	11KV	0.98
Panposh	11 kV Town feeder	11KV	0.93
Panposh	11 kV RGH feeder	11KV	1.00
Pilot Project	11 kV Pilot Project feeder	11KV	0.90
Industrial Estate	11 kV Industrial Estate feeder	11KV	0.80
Industrial Estate	11 kV Town feeder	11KV	0.82
Lathikata	11 kV Modern India-II feeder	11KV	0.88
Vedvyas	11 kV Vedvyas feeder	11KV	0.95
Vedvyas	11 kV Gopapali feeder	11KV	0.96

Table 20 - Power factor profile of 11 kV feeders

Harmonics profile

Voltage harmonics profile

Name of 33/11KV S/S	Nme of 11KV Feeder	THD V1	THD V2	THD V3
Basanti	11 kV DAV feeder	2.45 %	2.58 %	3.70 %
Basanti	11 kV PHD feeder	4.30 %	4.48 %	4.21 %
Koel Nagar	11 kV Jhirpani feeder	2.53 %	1.86 %	1.66 %
Koel Nagar	11 kV BC feeder	2.41 %	2.05 %	1.73 %
Koel Nagar	11 kV ADE feeder	1.62 %	2.04 %	2.28 %
Koel Nagar	11 kV Hamirpur feeder	1.84 %	1.75 %	2.18 %
Chhend	11 kV Panposh feeder	2.31 %	2.00 %	1.85 %
Chhend	11 kV RDA feeder	2.48 %	2.29 %	1.92 %
Chhend	11 kV Chend1st Phase feeder	1.70 %	1.66 %	1.58 %
Chhend	11 kV Luhakera feeder	1.79 %	2.16 %	3.40 %
Panposh	11 kV Raw water feeder	1.23 %	1.73 %	1.15 %
Panposh	11 kV College feeder	1.53 %	1.94 %	1.52 %
Panposh	11 kV RGH feeder	1.52 %	1.70 %	1.81 %
Pilot Project	11 kV Pilot Project feeder	1.77 %	1.35 %	1.72 %
Industrial Estate	11 kV Industrial Estate feeder	1.11 %	0.89 %	0.73 %
Vedvyas	11 kV Vedvyas feeder	5.85 %	5.97 %	6.55 %
Vedvyas	11 kV Gopapali feeder	4.23 %	4.69 %	4.80 %

Table 21 - Voltage harmonics profile

CURRENT HARMONICS PROFILE

Name of 33/11KV S/S	Nme of 11KV Feeder	THD I1	THD I2	THD I3
Basanti	11 kV DAV feeder	4.25 %	4.60 %	4.21 %
Basanti	11 kV PHD feeder	4.48 %	4.10 %	4.27 %
Koel Nagar	11 kV Jhirpani feeder	2.24 %	1.49 %	1.93 %
Koel Nagar	11 kV BC feeder	4.58 %	-	3.84 %
Koel Nagar	11 kV ADE feeder	3.77 %	-	3.84 %
Koel Nagar	11 kV Hamirpur feeder	4.14 %	3.63 %	5.94 %
Chhend	11 kV Panposh feeder	3.43 %	3.13 %	3.31 %
Chhend	11 kV RDA feeder	3.83 %	4.86 %	4.40 %
Chhend	11 kV Chend1st Phase feeder	3.73 %	4.08 %	4.76 %
Chhend	11 kV Luhakera feeder	4.94 %	5.12 %	3.91 %
Panposh	11 kV Raw water feeder	1.97 %	1.84 %	1.92 %
Panposh	11 kV College feeder	2.67 %	2.93 %	3.90 %
Panposh	11 kV RGH feeder	3.01 %	4.02 %	3.70 %
Pilot Project	11 kV Pilot Project feeder	3.66 %	4.41 %	4.29 %

Name of 33/11KV S/S	Nme of 11KV Feeder	THD I1	THD I2	THD I3
Industrial Estate	11 kV Industrial Estate feeder	3.45 %	4.12 %	3.92 %
Vedvyas	11 kV Vedvyas feeder	9.01 %	9.25 %	9.49 %
Vedvyas	11 kV Gopapali feeder	3.81 %	5.88 %	6.09 %

Table 22 - Current harmonics profile

Individual results of harmonics test by Zera MT300 equipment are as follows:

a. 11 kV DAV Feeder

	ID: WES50444	Date: 28.03.2019 Time: 10:39:27 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: DAV

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.76 %

	Absolute value	Angle
0	0.034842 %	0.000000°
1	100.000000 %	0.000000°
2	0.060909 %	23.693344°
3	0.481259 %	1.763153°
4	0.148741 %	38.032532°
5	1.858962 %	23.535400°
6	0.050069 %	50.407898°
7	2.332039 %	39.471699°
8	0.058490 %	37.953400°
9	0.161280 %	13.460876°
10	0.046538 %	23.534668°
11	1.964651 %	19.959930°
12	0.114676 %	13.449097°
13	0.627989 %	21.439741°

b. 11 kV PHD feeder

	ID: WSC32995	Date: 28.03.2019 Time: 10:29:01 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: PHD

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel UL1 Sum 42.27 %

	Absolute value	Angle
0	0.019884 %	0.000000°
1	100.000000 %	0.000000°
2	1.450987 %	5.050613°
3	40.736702 %	56.960403°
4	1.250590 %	30.651054°
5	7.370962 %	37.966797°
6	0.941063 %	37.799332°
7	6.693740 %	50.391804°
8	0.582959 %	41.147598°
9	3.334228 %	4.494568°
10	0.377518 %	5.449722°
11	1.618203 %	7.650635°
12	0.099293 %	12.046310°
13	2.366956 %	17.379423°

c. 11 kV Jhirpani feeder

	ID: WES48823	Date: 28.03.2019 Time: 18:57:46 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: JHIRPANI

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 1.77 %

	Absolute value	Angle
0	0.047270 %	0.000000°
1	100.000000 %	0.000000°
2	0.121497 %	64.749557°
3	0.205934 %	25.981033°
4	0.060502 %	42.692924°
5	0.877747 %	22.151482°
6	0.013889 %	20.884850°
7	1.154003 %	49.860809°
8	0.052848 %	31.003372°
9	0.208263 %	9.038063°
10	0.008701 %	0.000000°
11	0.874389 %	27.627594°
12	0.016378 %	7.156006°
13	0.324292 %	22.090849°

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d. 11 kV BC feeder

	ID: WES51231	Date: 28.03.2019 Time: 18:51:48 ZERA GmbH Type: MT300 No: 500320012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: CBKNGR

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.87 %

	Absolute value	Angle
0	0.016657 %	0.000000°
1	100.000000 %	0.000000°
2	0.269902 %	36.407364°
3	1.223689 %	103.625183°
4	0.018998 %	72.659241°
5	2.532934 %	13.341782°
6	0.121702 %	53.749607°
7	2.266454 %	38.765724°
8	0.161568 %	7.712055°
9	0.415157 %	15.706955°
10	0.123226 %	8.437729°
11	1.018891 %	15.530758°
12	0.025970 %	17.213066°
13	0.511113 %	11.393831°

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e. 11 kV ADE feeder

	ID: WSC07569	Date: 28.03.2019 Time: 18:44:23 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: ADESKNGR

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	05.000 A	3WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.96 %

	Absolute value	Angle
0	0.032644 %	0.000000°
1	100.000000 %	0.000000°
2	0.126285 %	160.554596°
3	1.301910 %	94.246521°
4	0.080625 %	48.795013°
5	3.042521 %	20.110321°
6	0.060495 %	49.291077°
7	1.716606 %	32.801899°
8	0.115256 %	34.653564°
9	0.104711 %	1.996613°
10	0.046970 %	23.060852°
11	1.139781 %	17.880951°
12	0.075585 %	0.551208°
13	0.312098 %	13.583754°

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f. 11 kV Hamirpur feeder

	ID: WEG00023	Date: 28.03.2019 Time: 18:38:02 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: HAMIRPUR

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 5.54 %

	Absolute value	Angle
0	0.094902 %	0.000000°
1	100.000000 %	0.000000°
2	0.242336 %	30.601273°
3	4.066596 %	57.634460°
4	0.082291 %	88.431152°
5	2.120742 %	70.824066°
6	0.233930 %	3.869339°
7	2.471306 %	26.940647°
8	0.148014 %	41.873840°
9	0.991361 %	6.566055°
10	0.357118 %	11.198425°
11	0.378390 %	9.084503°
12	0.060739 %	23.099243°
13	0.777983 %	27.402052°

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g. 11 kV Panposh feeder

	ID: WES52805	Date: 28.03.2019 Time: 16:24:16 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: PANPOSH

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.34 %

	Absolute value	Angle
0	0.034555 %	0.000000°
1	100.000000 %	0.000000°
2	0.133594 %	84.824440°
3	1.006621 %	38.157204°
4	0.062358 %	10.240761°
5	1.496788 %	10.106964°
6	0.079870 %	16.771782°
7	2.630152 %	32.282650°
8	0.079476 %	20.571617°
9	0.312122 %	23.170700°
10	0.049310 %	33.576157°
11	0.829714 %	12.955132°
12	0.090736 %	22.144730°
13	0.128702 %	25.393862°

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h. 11 kV RDA feeder

	ID: ORBS4763	Date: 28.03.2019 Time: 16:30:58 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: RDA

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 4.23 %

	Absolute value	Angle
0	0.092911 %	0.000000°
1	100.000000 %	0.000000°
2	0.261526 %	163.723022°
3	1.532055 %	32.111500°
4	0.259625 %	47.456383°
5	1.685079 %	9.242859°
6	0.067663 %	32.352802°
7	3.353499 %	27.076046°
8	0.033895 %	27.933098°
9	0.425736 %	21.350719°
10	0.097326 %	11.581543°
11	0.680362 %	9.782921°
12	0.017672 %	4.375572°
13	0.616329 %	1.790104°

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i. 11 kV Chhend 1phase feeder

	ID: ORBS4777	Date: 28.03.2019 Time: 16:17:38 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: P1CHEND

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	05.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 4.78 %

	Absolute value	Angle
0	0.021486 %	0.000000°
1	100.000000 %	0.000000°
2	0.206059 %	47.524822°
3	0.568505 %	33.530087°
4	0.121702 %	29.123615°
5	1.518048 %	9.571728°
6	0.083714 %	5.145618°
7	4.359261 %	32.510628°
8	0.064992 %	34.394974°
9	0.623578 %	30.678160°
10	0.109503 %	12.025608°
11	0.424343 %	11.741947°
12	0.053117 %	21.109592°
13	0.559078 %	5.648787°

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j. 11 kV Luhakera feeder

	ID: WES52804	Date: 28.03.2019 Time: 16:05:47 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: LUHAKERA

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	05.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 4.39 %

	Absolute value	Angle
0	0.184983 %	0.000000°
1	100.000000 %	0.000000°
2	0.603426 %	7.866722°
3	0.877533 %	29.672707°
4	0.075373 %	37.977894°
5	0.612877 %	29.776711°
6	0.137745 %	25.574387°
7	3.302133 %	43.690746°
8	0.205843 %	20.604828°
9	1.564552 %	14.907967°
10	0.077945 %	4.022797°
11	1.942009 %	28.554008°
12	0.028542 %	29.082146°
13	0.581575 %	9.794096°

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k. 11 kV Raw water feeder

	ID: WES52806	Date: 28.03.2019 Time: 12:45:39 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: ROWWATER

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 1.77 %

	Absolute value	Angle
0	0.031603 %	0.000000°
1	100.000000 %	0.000000°
2	0.154375 %	8.837471°
3	1.131396 %	101.011520°
4	0.112207 %	79.394226°
5	0.722111 %	18.445885°
6	0.070583 %	12.340431°
7	0.846340 %	34.275608°
8	0.039213 %	22.235260°
9	0.207501 %	28.247772°
10	0.051855 %	26.238220°
11	0.626683 %	27.221924°
12	0.018126 %	17.663773°
13	0.198845 %	25.288153°

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l. 11 kV College feeder

	ID: UPB54737	Date: 28.03.2019 Time: 13:08:05 ZERA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: 11KVCOLLEGE

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	05.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.84 %

	Absolute value	Angle
0	0.355851 %	0.000000°
1	100.000000 %	0.000000°
2	1.202047 %	149.339432°
3	1.820558 %	32.725113°
4	0.756522 %	49.468826°
5	1.080131 %	26.202568°
6	0.138093 %	20.699799°
7	2.252903 %	28.584354°
8	0.356958 %	41.897217°
9	0.670000 %	6.314110°
10	0.156240 %	20.276566°
11	0.555664 %	16.524597°
12	0.199689 %	19.257980°
13	1.255806 %	1.919369°

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m. 11 kV RGH feeder

	ID: WES50441	Date: 28.03.2019 Time: 12:59:00 ZIEGRA GmbH Type: MT300 No: 50032012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: RGHDF

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 173.81 %

	Absolute value	Angle
0	14.234972 %	0.000000°
1	100.000000 %	0.000000°
2	19.909140 %	38.638714°
3	24.488186 %	49.513496°
4	18.526695 %	30.278790°
5	21.370430 %	61.332741°
6	23.393061 %	37.666367°
7	7.241989 %	17.551617°
8	23.544167 %	10.082901°
9	13.320566 %	25.541695°
10	55.541790 %	21.670135°
11	58.787560 %	2.433983°
12	6.860557 %	28.968819°
13	12.991055 %	16.670248°

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n. 11 kV Pilot project feeder

	ID: ORB$4778	Date: 28.03.2019 Time: 15:05:34 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: PILOT

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.52 %

	Absolute value	Angle
0	0.341976 %	0.000000°
1	100.000000 %	0.000000°
2	0.074034 %	124.239685°
3	1.207490 %	84.185608°
4	0.193111 %	68.884834°
5	2.822306 %	41.428108°
6	0.071937 %	0.527092°
7	0.733613 %	29.499050°
8	0.230072 %	43.201279°
9	0.490674 %	3.904626°
10	0.259119 %	7.384697°
11	0.436163 %	5.346123°
12	0.187260 %	20.617105°
13	0.635779 %	24.378248°

o. 11 kV Industrial estate feeder

	ID: ORBS4890	Date: 28.03.2019 Time: 15:37:18 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: INDFDR

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 3.99 %

	Absolute value	Angle
0	0.058349 %	0.000000°
1	100.000000 %	0.000000°
2	0.247810 %	12.490112°
3	0.713037 %	77.653290°
4	0.147516 %	24.770851°
5	3.271261 %	0.639694°
6	0.077837 %	53.966675°
7	1.818959 %	44.927475°
8	0.221598 %	6.994080°
9	0.137223 %	36.543816°
10	0.107608 %	5.837555°
11	0.754842 %	28.109699°
12	0.026396 %	19.270081°
13	0.760665 %	26.646399°

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p. 11 kV Ved vyas feeder

	ID: WES52829	Date: 28.03.2019 Time: 14:09:42 ZERA GmbH Type: MT300 No: 500300/12

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: 11KVVEDVYAS

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 9.33 %

	Absolute value	Angle
0	0.657365 %	0.000000°
1	100.000000 %	0.000000°
2	0.663631 %	33.067703°
3	0.823455 %	29.534765°
4	0.135109 %	38.468445°
5	4.983150 %	53.855347°
6	0.192699 %	49.226563°
7	6.287161 %	44.374287°
8	0.162414 %	5.019150°
9	1.480972 %	38.423096°
10	0.257110 %	30.185669°
11	4.054345 %	17.820404°
12	0.585222 %	17.815643°
13	0.834630 %	16.461378°

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q. 11 kV Gopapalli feeder

	ID: WES52868	Date: 28.03.2019 Time: 13:57:05 ZERA GmbH Type: MT300 No: 50030012

Meter data

Manufacturer:
Manuf-No: Custom-No:
Operator: Supplier:

Location	Customer

MT300 adress: 11KVGOPOPALI

Measured values : Harmonics

	UB	IB	MM
Meas settings	250.0 V	C5.000 A	4WA
U-Ratio	1.0/1.0		
I-Ratio	1.000/1.000		
	Actual Values	Meter-Constant	Meter-Register
Ratio cons.	On	On	On

Channel IL3 Sum 5.73 %

	Absolute value	Angle
0	0.084115 %	0.000000°
1	100.000000 %	0.000000°
2	0.157439 %	88.967773°
3	0.842698 %	50.431061°
4	0.295288 %	40.600464°
5	4.443768 %	65.926941°
6	0.174137 %	36.718689°
7	0.929909 %	11.428562°
8	0.102553 %	1.548179°
9	0.478505 %	5.598329°
10	0.315536 %	13.547211°
11	3.120842 %	14.217285°
12	0.153656 %	26.255676°
13	0.630659 %	13.936415°

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Transformer failure rate

Rourkela Electrical Division (RED) transformer failure

Installed		Failed DTs in FY 2017-18												
Capacity	Nos.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
10 kVA	0													0
16 kVA	210		1		2	1	4	4	2		1	1		16
25 kVA	59			3	1	5	1	8	1		3			22
63 kVA	36		2			1			2		1	1		7
100 kVA	142	4	4		3		3	2		2		1	1	20
150 kVA	6													0
160 kVA	1													0
200 kVA	12				1									1
250 kVA	78			1	1	1								3
300 kVA	0													0
315 kVA	19													0
400 kVA	4													0
500 kVA	50		1		1							1		3
630 kVA	6					1								1
750 kVA	1													0
1000 kVA	1													0
Total	**625**	**4**	**8**	**4**	**9**	**9**	**8**	**14**	**5**	**2**	**5**	**4**	**1**	**73**

Total transformers in RED division = 625
No. of failed transformers in 2017-18 = 73 - % failure rate = 73 / 625 = 11.68%

However, since 10, 16 and 25 kVA transformers are HVDS single consumer DTs with high failure rate, it might be excluded.
Therefore, % failure rate of RED division = 35 / 625 = 5.60%

Rourkela Sadar Electrical Division (RSED) transformer failure

Installed		Failed DTs in FY 2017-18												
Capacity	Nos.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
10 kVA	70													0
16 kVA	875	1	1	1	2	12	6	2	1	1			1	28
25 kVA	898				2	6	1	2			1			12
63 kVA	236				1			1		1			1	4
100 kVA	266	4	1		6	1		2			1			15
150 kVA	4													0
160 kVA	0													0
200 kVA	6													0
250 kVA	74			1		1								2
300 kVA	1													0
315 kVA	17					2								2
400 kVA	2													0
500 kVA	30	3		1			1					1		6
630 kVA	1													0
750 kVA	0													0
1000 kVA	0													0
Total	**2480**	**8**	**2**	**3**	**11**	**22**	**8**	**7**	**1**	**2**	**2**	**1**	**2**	**69**

Total transformers in RSED division = 2480
No. of failed transformers in 2017-18 = 69 - % failure rate = 89 / 2480 = 2.78%

However, since 10, 16 and 25 kVA transformers are HVDS single consumer DTs with high failure rate, it might be excluded.
Therefore, % failure rate of RSED division = 29 / 2480 = 1.17%

Rourkela Sadar Electrical Division (RSED) transformer failure

Installed		Failed DTs in FY 2017-18												
Capacity	Nos.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
10 kVA	70													0
16 kVA	875	1	1	1	2	12	6	2	1	1			1	28
25 kVA	898				2	6	1	2			1			12
63 kVA	236				1			1		1			1	4
100 kVA	266	4	1		6	1		2			1			15
150 kVA	4													0
160 kVA	0													0
200 kVA	6													0
250 kVA	74			1		1								2
300 kVA	1													0
315 kVA	17					2								2
400 kVA	2													0
500 kVA	30	3		1			1					1		6
630 kVA	1													0
750 kVA	0													0
1000 kVA	0													0
Total	**2480**	**8**	**2**	**3**	**11**	**22**	**8**	**7**	**1**	**2**	**2**	**1**	**2**	**69**

Total transformers in RSED division = 2480
No. of failed transformers in 2017-18 = 69 - % failure rate = 89 / 2480 = 2.78%

However, since 10, 16 and 25 kVA transformers are HVDS single consumer DTs with high failure rate, it might be excluded.
Therefore, % failure rate of RSED division = 29 / 2480 = 1.17%

Total transformer failure for FY 2017-18

Installed		Failed DTs in FY 2017-18												
Capacity	Nos.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
10 kVA	70	0	0	0	0	0	0	0	0	0	0	0	0	0
16 kVA	1085	1	2	1	4	13	10	6	3	1	1	1	1	44
25 kVA	957	0	0	3	3	11	2	10	1	0	4	0	0	34
63 kVA	272	0	2	0	1	1	0	1	2	1	1	1	1	11
100 kVA	408	8	5	0	9	1	3	4	0	2	1	1	1	35
150 kVA	10	0	0	0	0	0	0	0	0	0	0	0	0	0
160 kVA	1	0	0	0	0	0	0	0	0	0	0	0	0	0
200 kVA	18	0	0	0	1	0	0	0	0	0	0	0	0	1
250 kVA	152	0	0	2	1	2	0	0	0	0	0	0	0	5
300 kVA	1	0	0	0	0	0	0	0	0	0	0	0	0	0
315 kVA	36	0	0	0	0	2	0	0	0	0	0	0	0	2
400 kVA	6	0	0	0	0	0	0	0	0	0	0	0	0	0
500 kVA	80	3	1	1	1	0	1	0	0	0	0	2	0	9
630 kVA	7	0	0	0	0	1	0	0	0	0	0	0	0	1
750 kVA	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1000 kVA	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3105	12	10	7	20	31	16	21	6	4	7	5	3	142

Total transformers in Smart city area = 3105
No. of failed transformers in 2017-18 = 142 - % failure rate = 142 / 3105 = 4.57%

However, since 10, 16 and 25 kVA transformers are HVDS single consumer DTs with high failure rate, it might be excluded.

Therefore, % failure rate = 64 / 3105 = 2.06%