Summary

of

Baseline Study

on

Establishment of

Key Performance Indicators (KPIs)

for

Implementation of Smart Grid in

Rourkela Smart City

Prepared by

PFC Consulting Ltd.

9th Floor, Statesman House

Barakhamba Road

Connaught Place, New Delhi-110001

Phone: 011-23443900, Fax: 011-23443990

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1. Brief Profile of Rourkela Smart City

1.1 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), which is one of the four distribution utilities catering to Western part of Odisha with its headquarters at Burla.

1.2 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, namely-

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

1.3 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

1.4 It is envisaged that Smart Grid implementation in Rourkela will bring about 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

1.5 Administratively, Rourkela Electrical 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 – rest of its feeders cater to areas purely outside Smart city boundary. 33 kV network comes under the purview of Odisha Power Transmission Corporation Ltd (OPTCL).

1.6 OPTCL has appointed PFC Consulting Ltd (PFCCL) for undertaking various activities for development and implementation of Smart Grid in Rourkela city.

1.7 In order to commence implementation of the project, a set of important Key Performance Indicators (KPIs) have been established so that the current values of these KPIs may serve as a baseline. Any post-implementation improvements can be measured based on the change in values of the KPIs.

1.8 The baseline KPIs covered under the project are as follows –

AT&C Loss

- Input Energy (as per ring fencing)
- Technical Losses based on asset (DT, feeder, etc) and Voltage level
- Commercial Losses based on units measured, billed, collected, defective meters

System reliability indices

- SAIFI (System Average Interruption Frequency Index)
- SAIDI (System Average Interruption Duration Index)
- CAIDI (Customer Average Interruption Duration Index)

Power quality parameters

- Voltage profile
- PF profile
- Harmonics profile at selected substations

DT failure rate

- Distribution transformers failure per year in project area

Figure 1 - List of Baseline KPIs covered under the project

2. Existing Infrastructure of Rourkela Smart City Area

2.1 Existing electrical infrastructure which caters to Rourkela Smart City area is given below:

Sl. No.	Particulars	UoM	Value
1	Total No. of 33 KV Sub-stations feeding the Project Area	Nos.	14
2	Total Number of Power Transformers at 33 KV S/S	Nos.	30
3	Total Capacity of Power Transformers at 33 KV S/S	MVA	199
4	Total Number of 33 kV Feeders	Nos.	10
5	Total Length of 33 kV Feeders	Ckt Kms	72
6	Total Number 11 kV Feeders	Nos.	31
7	Total Length of 11 kV Feeders	Ckt Kms	225
8	No of 33KV/ 0.4 KVA DT	Nos.	9
9	Capacity of 33KV/0.4 KVA DT	MVA	3
10	Total Length of LT Lines	Ckt Kms	370
11	Total Number of Distribution Transformers	Nos.	1180
12	Total Capacity of Distribution Transformers (11KV/ 0.4 KV)	MVA	163

Table 1 - List of existing electrical infrastructure in Rourkela Smart City

3. Consumer Data

3.1 Rourkela Smart City area caters to around 81,659 consumers. With only 2 consumers connected at the 33 kV level (only within Smart City), bulk of the consumer base is connected at 11 kV and LT level.

3.2 WESCO has mapped the consumers based on appropriate feeder codes. This makes it easier for calculation of feeder-wise energy sales and hence helps in energy audit. However, the challenge lies in keeping the consumer tagging updated in database since frequent changes in network orientation can distort the energy audit results.

3.3 An 11kV feeder-wise break-up of consumers is given below for reference –

Division	33 / 11 kV Substation	Feeder Name	Feeder Code	No. of Consumers
RSED	33 / 11 kV Chend	11 kV Self Finance	BFBF	2,203
RSED	33 / 11 kV Chend	11 kV Panposh	BFBB	2,572
RSED	33 / 11 kV Chend	11 kV RDA	BFBC	1,925
RSED	33 / 11 kV Chend	11 kV Chend 1st Phase	BFBA	4,023
RSED	33 / 11 kV Chend	11 kV Kalingavihar	BFBE	2,931
RSED	33 / 11 kV Chend	11 kV Luhakera	BFBD	1,262
RSED	33 / 11 kV Panposh	11 kV PHD	AFAD	29
RSED	33 / 11 kV Panposh	11 kV Raw Water	AFAA	1,357
RSED	33 / 11 kV Panposh	11 kV College	AFAB	2,868
RSED	33 / 11 kV Panposh	11 kV Town	AFAC	3,529
RSED	33 / 11 kV Pilot Project	11 kV Pilot Project	AEAA	19
RSED	33 / 11 kV Industrial Estate	11 kV Industrial Estate	ADAB	3,353
RSED	33 / 11 kV Industrial Estate	11 kV Town	ADAA	624
RSED	33 / 11 kV Lathikata	Modern India-II	AIAB	7,643
RED	33 / 11 kV PH Road	11 kV Udit Nagar	ABAD	3,069
RED	33 / 11 kV PH Road	11 kV Main Road	ABAB	3,255
RED	33 / 11 kV PH Road	11 kV Power House Road	ABAC	1,626
RED	33 / 11 kV PH Road	11 kV Plant Site Road	ABAA	4,083
RED	33 / 11 kV Basanti	11 kV DAV	BEAA	5,006
RED	33 / 11 kV Basanti	11 kV PHD	BEAB	2,267
RED	33 / 11 kV Basanti	11 kV MS Palli	BEAC	5,042
RED	33 / 11 kV REC	11 kV Jagda/Shaktinagar	AAAB	2,536
RED	33 / 11 kV REC	11 kV Nayabazaar Bondamunda	AAAA	6,584
RED	33 / 11 kV REC	11 kV OSAP	AAAD	3,774
RED	33 / 11 kV Koel Nagar	11 kV Jhirpani	BFAA	2,259
RED	33 / 11 kV Koel Nagar	11 kV BC	BFAB	2,023
RED	33 / 11 kV Koel Nagar	11 kV ADE	BFAC	3,186
RED	33 / 11 kV Koel Nagar	11 kV Hamirpur	BFAD	1,928
RJP	33 / 11 kV Ved Vyas	11 kV Ved Vyas		555
RJP	33 / 11 kV Ved Vyas	11 kV Gopapalli		128
Total consumers				81,659

Table 2 - 11 kV feeder-wise consumers in Rourkela Smart City

4. Methodology for Baseline AT&C Loss Verification

4.1 PFC has issued a Guideline in September 2009 on methodology for AT&C calculation.

4.2 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. However, in this study data for FY 2017-18 and FY 2018-19 has been collated and analyzed in order to account for seasonal variations.

4.3 The following four-step approach for baseline verification has been followed:

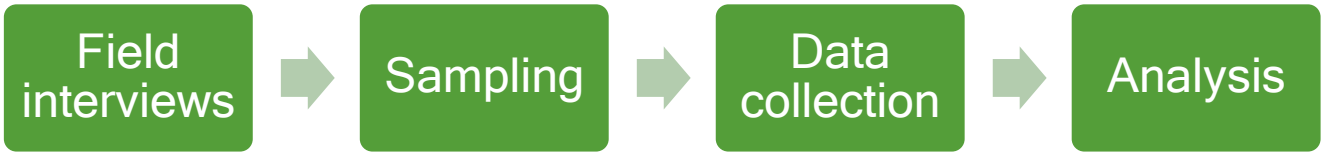

Figure 2 - Methodology for verification

5. Field Interviews

5.1 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 under WESCO which are covered under the area of Smart City project.

6. Methodology of Sampling, Data Collection & Analysis

6.1 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.

6.2 The methodology used for sampling is 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 3 - Methodology used for sampling

7. Ring fencing & input points

7.1 According to PFC's 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*."

7.2 Therefore, the electrical network of Rourkela has been studied in order to determine import and export points for Smart City area.

7.3 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

7.4 Out of these three areas, RMC area would 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.

7.5 Determination of Ring Fencing

7.5.1 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).

7.5.2 Further, 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.

7.5.3 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 (till Q3) is given below:

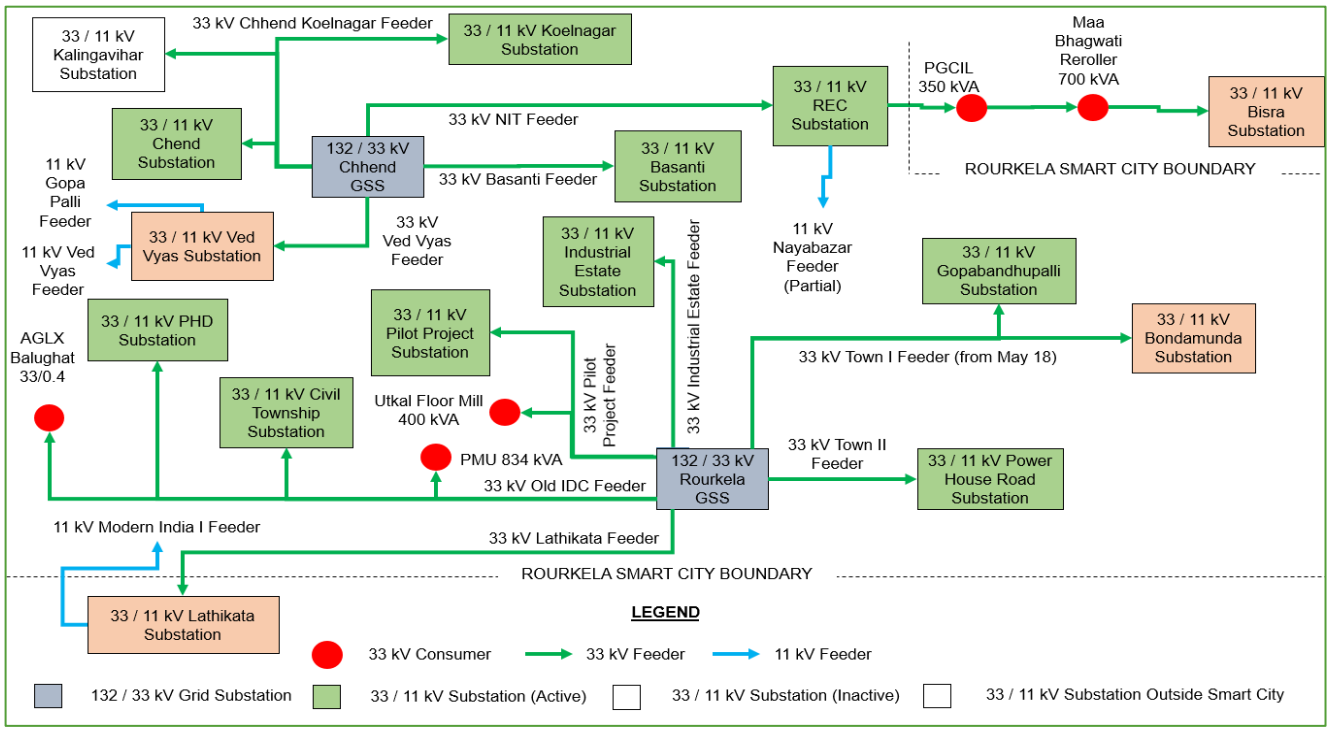

Figure 3 - 33 kV network configuration for FY 18-19

8. Steps for AT&C loss verification

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

8.1.1 **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 at end of year – Meter reading at beginning of year) x Multiplying factor

8.1.2 **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 of WESCO which has been used in deriving billing and collection for HT consumers. With these data, the billing efficiency of the 33 kV feeder has been 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)

8.1.3 **Step 3:** Collection Efficiency has been determined as per the following:

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)

8.1.4 **Step 4:** AT & C for 33 kV feeder has been calculated as per the following formula:

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

9. Baseline Study Results

Parameter	UoM	FY 2017-18	FY 2018-19
Input Energy	Lakh Unit (LU)	3,186.14	2,963.80
Billed Energy	Lakh Unit (LU)	2,237.06	2,396.70
Billed Amount	INR Lakh	11,946.17	13,302.22
Collected Amount	INR Lakh	11,394.86	12,436.97
Billing Efficiency	%	70%	81%
Collection Efficiency	%	95%	93%
AT&C loss	**%**	**30%**	**24%**

Table 4 - Final results of AT&C loss verification

9.1 Technical loss at 33 kV level is 2.45% & technical loss at 11 kV system (sample feeders) is 7.49%.

9.2 Voltage at 33 kV and 11 kV level is within permissible limits whereas power factor and harmonics are also within permissible limits.

9.3 Transformer failure stands at 2.06% only (excluding HDVS transformers)