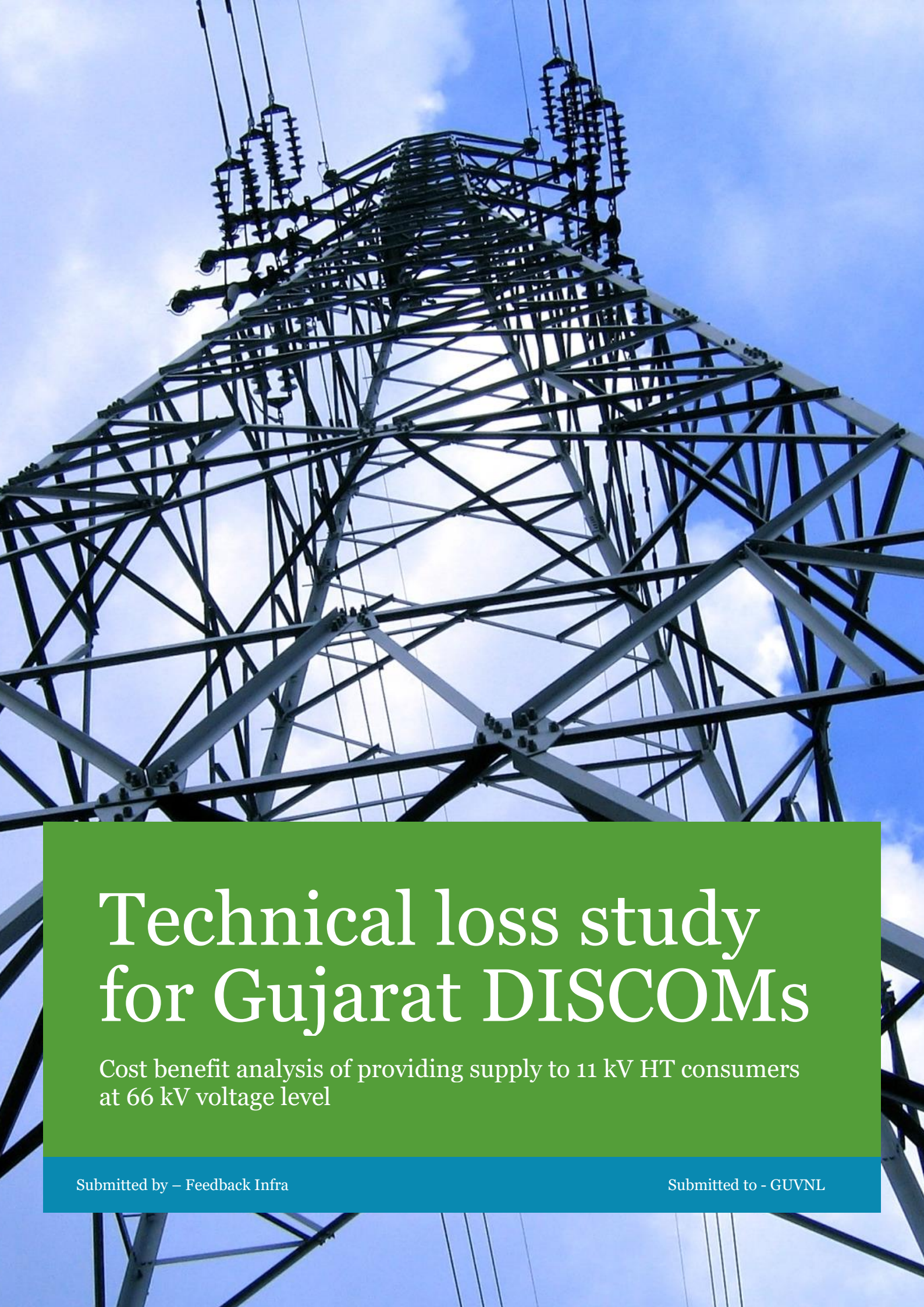




# Technical loss study for Gujarat DISCOMs

Cost benefit analysis of providing supply to 11 kV HT consumers  
at 66 kV voltage level

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Submitted to - GUVNL

## Executive Summary

Gujarat DISCOMs provide power supply to HT bulk consumers at 11kV as well as 66 kV voltage level. While supplying energy at 11 kV is cost effective, the technical losses in 11 kV system are higher than losses at 66 kV voltage level as the current drawn for 11 kV is 6 times that of 66 kV level for same power demand. On the other hand, 66 kV systems are costlier owing to higher insulation cost as well as equipment and line construction costs. 66 kV supply also faces lesser interruption compared to 11 kV and has better voltage regulation.

This study has been conducted as per directions of hon'ble GERC to evaluate the cost-benefit involved in supplying power at 66 kV level voltage to high value consumers catered by Gujarat DISCOMs. Both conventional as well as ETAP loss calculation methodologies have been used for the purpose of this study. Sample 11 kV feeders have been taken from all four DISCOMs with varied configuration (underground / overhead), line length and load factors so as to capture representations of the entire population of industrial feeders in Gujarat.

The consultant has taken note of the fact that extending 66 kV network in license area of Gujarat DISCOMs is comparatively more difficult than 11 kV owing to Right of Way (RoW) issues. Hence, in most cases, 66 kV supply is rendered through underground XLPE cables rather than overhead lines. Therefore, while choosing augmented 66 kV network for sample consumers, 9:1 ratio, i.e., 90% underground cables and 10% overhead lines have been considered. Furthermore, 66 kV XLPE cables cost approximately INR 1.84 Cr. per circuit kilometre compared to about INR 0.15 Cr in case of overhead line of same length.

After objective evaluation, it has been found that conversion to 66 kV may be unviable since the payback period comes to more than 10 years on average.

The following cost and saving can be determined for standard industrial loads –

| Contract Demand (kVA) | Per kVA cost of conversion (INR.) | Per kVA saving potential (INR.) | Conversion cost (INR. Cr.) | Saving (INR. Cr.) |
|-----------------------|-----------------------------------|---------------------------------|----------------------------|-------------------|
| 200                   | 23,960                            | 162.70                          | 0.48                       | 0.003             |
| 500                   | 23,960                            | 162.70                          | 1.20                       | 0.01              |
| 1,000                 | 23,960                            | 162.70                          | 2.40                       | 0.02              |
| 1,500                 | 23,960                            | 162.70                          | 3.59                       | 0.02              |
| 2,000                 | 23,960                            | 162.70                          | 4.79                       | 0.03              |

Chapter 4 to 7 outline the DISCOM-wise calculation for conversion while results of the technical loss study are summarised in Chapter 8.

Chapter 9 deals in calculation of voltage level-wise cost of supply. This study has been done for express feeders only. The study allocates power purchase cost and network related costs for derivation of voltage-wise cost of supply. Results of derivation of voltage level-wise cost of supply are given as follows

| Voltage level | Cost of power purchase (INR / unit) | Network cost (INR / unit) | Cost of supply (INR / unit) |
|---------------|-------------------------------------|---------------------------|-----------------------------|
| 11 kV         | 4.34                                | 0.15                      | 4.49                        |
| 66 kV         | 4.30                                |                           | 4.30                        |

The differential of the above cost of supply (INR. 0.19 per unit) may be appropriately passed on to consumers opting for 66 kV supply instead of 11 kV supply. The appropriate proportion of benefit to be passed on may be decided by hon'ble GERC.

Furthermore, HT tariffs of other states have been discussed in Chapter – 10. Whereas, technical impact study for 66 kV conversion and loss impact for direct supply feeders are discussed in Chapters 11 and 12.

As per findings of the study conducted, although conversion of voltage level to 66 kV shall result in reduced loss levels, however the cost of 66 kV conversion is too high to recover within reasonable payback period. It is noted that 33 kV supply is a more viable option for power supply at high voltage for avoiding losses.

33 kV voltage is standard for sub-transmission level in most DISCOMs in India. It has the following advantages –

- Lesser cost footprint than 66 kV for underground cables, transformers, circuit breakers, etc.
- Standard designs for 33/11 kV and 33 / 0.4 kV transformers with more options and configurations of switchgear
- Better voltage regulation and loss vis-à-vis 11 kV level

In most parts of India, 33 kV voltage level is under purview of DISCOMs. In Gujarat, similar stance may be taken so that if introduced, 33 kV level may be handled by DISCOMs.

In the matter of supplying multiple consumers from same 66 kV feeder, an in-depth short circuit study has been conducted and it has been evaluated that the present breaking capacity of 31.5 kA being used by GETCO is sufficient for handling the fault level in case of supply to multiple consumers through tapping of single 66 kV feeder. However, in interest of power reliability, it has been suggested to adopt LILO approach using either conventional 72.5 kV circuit breakers or GIS hybrid circuit breakers in case of shortage of space to install protection equipment.

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# CHAPTER: 1 OVERVIEW OF TECHNICAL LOSS STUDY

## Introduction

### Directives issued by GERC in Tariff Orders for FY 2018-19

Gujarat State Electricity Commission (GERC) had issued fresh directives to Gujarat State DISCOMs in their respective tariff orders on 31<sup>st</sup> March 2018. The relevant ‘Fresh Directives’<sup>1</sup> issued by GERC are listed below:

**Directive 2:** In order to promote supply at higher voltages, the Commission is of the view that consumers should be appropriately incentivised for availing supply at EHV. At present there is a provision of giving rebate to such EHV consumers in terms of percentage to the energy charges. DISCOMs are directed to carry out a detailed study to work out cost of supply at EHV level, reduction in technical loss for supplying electricity at higher voltages.

**Directive 4:** It is required to match the electricity demand curve with the availability of electricity supply and in order to optimise the overall cost of electricity supply to consumers and to move towards recovery of cost of supply according to time of use of electricity supply, Commission would like to introduce Demand Response measures. Accordingly, the Distribution Licensee is directed to initiate study for implementing ‘Demand Response’ measures and submit its Action Plan accordingly.

### Engagement of consultants by GUVNL

Accordingly, Gujarat Urja Vikas Nigam Limited (GUVNL) has appointed M/s Feedback Infra Private Limited as consultants for conducting studies based on the above-mentioned directives after a cost-based tender evaluation process. As per Letter of Award No. GUVNL/COM/Study/2018/661 dated 19<sup>th</sup> June, 2018, the broad scope of work is as follows:

- ≡ To work out cost of supply at EHV level and reduction in technical loss for supplying electricity at higher voltage – *(as per directive 2 of GERC)*
- ≡ For implementing Demand Response Measures and its action plan – *(as per directive 4 of GERC)*

## Brief Details of GUVNL

**Gujarat Urja Vikas Nigam Limited (GUVNL)** is the umbrella company for all the electrical services in state of Gujarat. GUVNL was formed in 1999 under Companies Act 1956.

As a part of Power Reform Process, the Electricity Act, 2003, was passed by the Central Government and Gujarat Electricity Industry (Re-organization & Regulation) Act, 2003, was passed by Gujarat

<sup>1</sup> Tariff Order for Truing up for FY 2016-17 and Determination of Tariff for FY 2018-19

Government after that Gujarat Electricity Board (GEB) was unbundled into Seven Companies with functional responsibilities of Trading, Generation, Transmission and Distribution etc.

After unbundling following companies were incorporated:

|                                                             |                                                 |
|-------------------------------------------------------------|-------------------------------------------------|
| <b>Gujarat Urja<br/>Vikas Nigam<br/>Limited<br/>(GUVNL)</b> | ≡Gujarat State Electricity Corp. Ltd. (GSECL)   |
|                                                             | ≡Gujarat Energy Transmission Corp. Ltd. (GETCO) |
|                                                             | ≡Uttar Gujarat Vij Company Ltd. (UGVCL)         |
|                                                             | ≡Paschim Gujarat Vij Company Ltd. (PGVCL)       |
|                                                             | ≡Madhya Gujarat Vij Company Ltd. (MGVCL)        |
|                                                             | ≡Dakshin Gujarat Vij Company Ltd. (DGVCL)       |

Since 100% Shares in the other six companies are held by GUVNL they have become Subsidiary Companies of GUVNL as per the provisions of the Companies Act,1956.

## Scope of Work

This project covers study for below listed activity:

- ≡ To work out cost of supply at EHV level and reduction in technical loss for supplying electricity at higher voltage.
- ≡ For implementing Demand Response Measures and its action plan as directed by Gujarat Electricity Regulatory Commission (GERC).

To carry out study following activities need to be undertaken:

- I. Activities to carry out a detailed study to work out cost of supply at EHV level, reduction in technical loss for supplying electricity at higher voltages as under:
  - ≡ Analysis for selection of 11 KV feeders with consumer having demand @ 2500-4000 KVA to undertake exact impact on the existing network including line losses in case the same consumer is supplied at EHV level.
  - ≡ Similarly, analysis for selection of 66 KV feeders with consumer having demand @ 2500-4000 KVA to undertake study of existing level of 66 KV network line losses for supply of same quantum of power at EHV level.
  - ≡ Selection of sample feeders of HV/EHV feeder with different configuration for undertaking base analysis and loss estimation for supply of power at 11 KV and 66 KV voltage level considering historical data.
  - ≡ Network details /information of selected sample feeder such as drawings for network to be studied, peak loading, loading pattern on network segment for undertaking base line data analysis.
  - ≡ Standard Network simulation analysis software / tool suitable for undertaking load flow/ network analysis on selected feeders.

- ≡ The output of the software shall be validated in mutually agreed time to ensure processing of data for each feeder and network segment.
- ≡ Comparative analysis on sample feeders for supply of power at 11 KV vis-a-vis 66 KV level.
- ≡ To study feasibility of supply to more than one consumer through single EHV feeder and its impact on losses.
- ≡ Analysis for cost of supply for supplying power at 11 KV voltage level as per base analysis undertaken for sample feeder.
- ≡ Analysis for cost of supply for supplying power at 66 KV voltage level as per base analysis undertaken for sample feeder.
- ≡ Study of network behaviour for different type of loading condition and technical impact of higher voltage including on cost of supply and line losses.
- ≡ Methodology for determination of HT and EHT losses of network based on result of sample feeder analysis and quantification of reduction in technical loss for supplying electricity at higher voltages for network as a whole and to work out cost of supply at HV and conversion cost thereof.
- ≡ Study and suggestion in regard to viable mechanism to pass on benefit due to supply at higher voltage level to the consumers.
- ≡ Overall Cost benefit study for supply at higher voltage in context to both consumers and DISCOMs.
- ≡ Study and comparative analysis rebate / benefit provided to EHV consumers in other States.

II. Activities to carry out a detailed study for implementing 'Demand Response' measures and prepare its Action plan:

- ≡ Study and analysis of different demand response measures/techniques implemented nationally / internationally and lessons learnt.
- ≡ Selection of sample feeder for undertaking study of hourly data in regard to time of consumption, type of consumption for baseline analysis and potential of 'Demand Response' mechanism.
- ≡ Study electricity demand curve with the availability of electricity supply and in order to optimise the overall cost of electricity supply to consumers and to give signal to targeted consumers to shift their consumption/load in accordance with demand - supply gap/ surplus scenario and move towards recovery of cost of supply according to time of use of electricity supply.
- ≡ Study and analysis of DISCOM-wise load profile, consumers connected load, electricity consumption, cost of supply, average billing, peak demand and its timings etc.
- ≡ Study DISCOM-wise power procurement costs (short term, long term, exchange etc.).
- ≡ Identification of load / consumer categories most suitable for covering under demand response program considering the existing metering infrastructure and communication system available. Participation of consumer behaviour and impact on billing system.
- ≡ Identification of Demand Response mechanism in accordance with demand-supply curve of DISCOM so that targeted consumers will get tariff benefits for shifting their non- critical load in low tariff period in order to reduce overall supply cost of DISCOM and to reduce peak demand and make flatten demand curve.
- ≡ Preparation of detailed plan for Demand response measures - consumer load survey, incentive mechanism, metering and network infrastructure adequacy / requirement, consumer enrolments process, consumer registration process, baseline establishment pre- Demand Response events, monitoring and verification mechanism, validation of benefits from Demand Response events to DISCOMs.

## Study Background

Gujarat DISCOMs combined have a total of approximately 1068 number of consumers with contract demand between 2.5 MVA to 4 MVA. Out of these, about 683 consumers are connected at 11 kV voltage level with combined contract demand of about 1950 MVA.

| DISCOM       | Number of Consumers | Contract Demand (MVA) | Units Consumed (MWh) | Load Factor (%) |
|--------------|---------------------|-----------------------|----------------------|-----------------|
| <b>DGVCL</b> | 105                 | 289                   | 1,274,485            | 56%             |
| <b>MGVCL</b> | 90                  | 259                   | 1,039,719            | 51%             |
| <b>PGVCL</b> | 314                 | 880                   | 3,077,093            | 44%             |
| <b>UGVCL</b> | 174                 | 522                   | 1,953,920            | 47%             |
| <b>Total</b> | 683                 | 1950                  | 7,345,218            | 48%             |

Table 1 - Statistics of 11 kV consumer (FY 2017-18)<sup>2</sup>

It is observed that due to supply at 11 kV level, there are inherent technical losses in the system owing to higher I<sup>2</sup>R loss. Theoretically, there is potential for reduction in these losses by supplying power to these consumers at the next higher voltage level which is 66 kV as per Gujarat DISCOMs standard of supply. A part of the benefit accruing out of supplying at 66kV voltage level can be passed on to consumers in terms of reduced tariff.

However, in order to supply power to these consumers at 66 kV level, investment shall be required on the part of DISCOMs for creating new 66 kV bays, circuit breakers, transmission lines etc. Consumers shall also be required to invest in new transformers, breakers, associated equipment and yard.

Therefore, cost-benefit study is required to arrive at a pragmatic and correct decision which shall be beneficial to both DISCOMs as well as consumers.

## Objective

The purpose of this study is to:

- ≡ Select appropriate sample size of 11 kV consumers and carry out loss and network analysis for supply at 66 kV level
- ≡ Conduct similar analysis on existing 66 kV consumers to validate the results of 11 kV converted consumers
- ≡ Study the feasibility of supply to more than one consumer through single 66 kV feeder and impact on losses
- ≡ Analysis of cost of supply for 11 kV and 66 kV level
- ≡ Overall cost-benefit analysis for supply at 66 kV for both consumers as well as DISCOMs
- ≡ Comparative analysis of rebates / benefits provided to EHV consumers in other states

<sup>2</sup> Source – GUVNL commercial department MIS

## CHAPTER: 2 SELECTION OF SAMPLE FEEDERS

### Basis of Selection of 11 kV Feeders

In order to carry out the study, about 153 numbers of 11 kV industrial feeders have been selected of varying line length, configuration and load types. Most of these feeders are HT express feeders. These 11 kV express feeders typically emanate from a 66 / 11 kV substation and feed directly to one HT industry connected at 11 kV voltage level. The feeders have been chosen in such a manner so as to cover industries within the range of 2.5 MVA to 4 MVA. The methodology of sampling and data collection is depicted in the following flowchart –

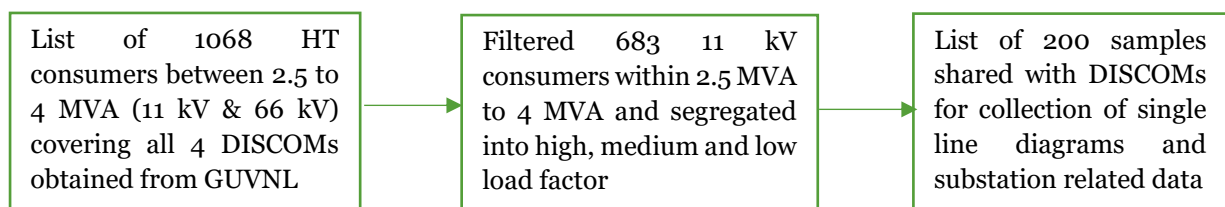


Figure 1 - Flowchart for sample selection of Feeders

Out of ~200 feeders, 153 11 kV feeders were selected based on data availability.

### Statistics of selected 11 kV feeders

As mentioned above, a total of 153 feeders have been selected from the DISCOMs. DISCOM-wise break-up is presented below -

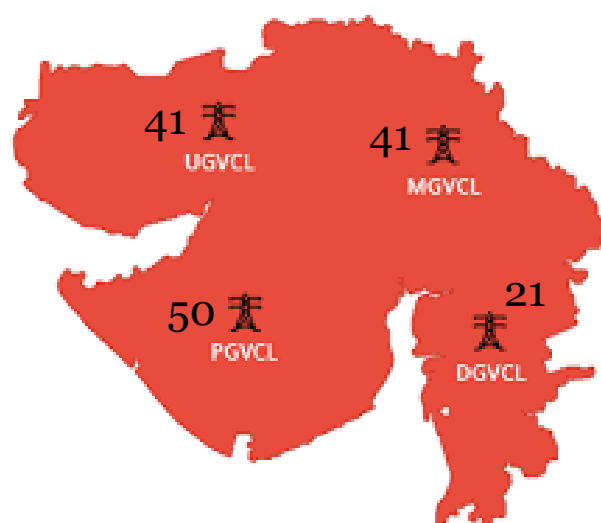


Figure 2 - DISCOM-wise break-up of sample 11 kV feeders

All types of industrial units have been covered under the sample study in totality. Details of industry-types are given as follows –

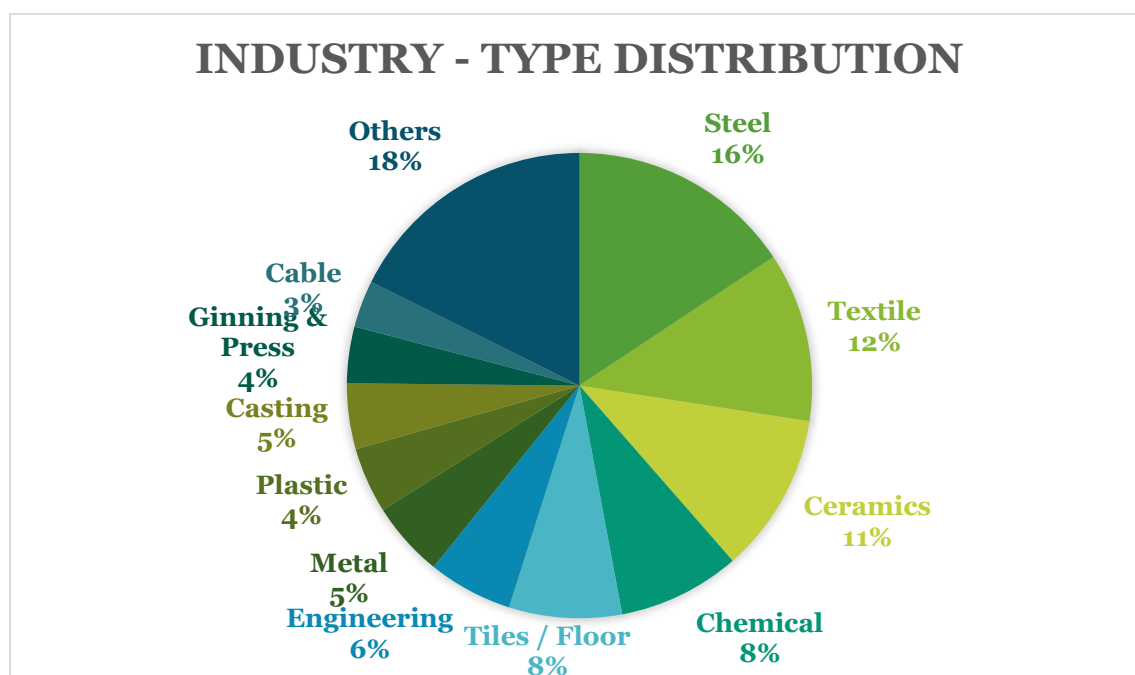


Figure 3 - Industry-types covered under 11 kV feeder sample

## Ensuring different configuration of 11 kV feeders

For the purpose of comprehensive study, it is imperative that all types of feeder configurations such as overhead, underground, etc. Therefore, adequate representation of all the important configurations have been considered as follows –

| Feeder type                     | Number of Feeders |
|---------------------------------|-------------------|
| Overhead - bare conductor       | 111               |
| Overhead – Aerial Bunched Cable | 5                 |
| Underground Cable               | 37                |

Table 2 - Break-up of overhead and underground samples of 11 kV feeders

Further, size-wise break-up of sample 11 kV feeders are given below for reference. Representation from all existing configuration types in the sample will ensure that adequate conclusion can be drawn based on the study as both losses and investment significantly vary as per the line configuration. Typically, XLPE cables incur less losses than bare conductor overhead lines for the same length. However, capital cost of XLPE cables is more than 4-5 times of overhead line.

| Line configuration | Size | Number of Feeders |
|--------------------|------|-------------------|
| Overhead           |      |                   |

| Line configuration                  | Size                          | Number of Feeders |
|-------------------------------------|-------------------------------|-------------------|
| - <b>ACSR Conductor</b>             | Panther – 200 mm <sup>2</sup> | 1                 |
| - <b>ACSR Conductor</b>             | Dog – 100 mm <sup>2</sup>     | 46                |
| - <b>ACSR Conductor</b>             | Rabbit – 55 mm <sup>2</sup>   | 6                 |
| - <b>AAAC Conductor</b>             | Dog – 100 mm <sup>2</sup>     | 40                |
| - <b>AAAC Conductor</b>             | Rabbit – 55 mm <sup>2</sup>   | 18                |
| - <b>Aerial Bunched Cable (ABC)</b> | 70 mm <sup>2</sup>            | 1                 |
| - <b>Aerial Bunched Cable (ABC)</b> | 90 mm <sup>2</sup>            | 4                 |
| <b>Underground</b>                  |                               |                   |
| - <b>XLPE Aluminium Cable</b>       | 185 mm <sup>2</sup>           | 35                |
| - <b>XLPE Aluminium Cable</b>       | 240 mm <sup>2</sup>           | 2                 |
|                                     |                               |                   |
| <b>Total</b>                        |                               | <b>153</b>        |

Table 3 - Size-wise break-up of line configuration for 11 kV feeder samples

Furthermore, the 11 kV feeders have been classified into different groups based on line length (in circuit kilometers) and Load Factor (LF) of the consumer connected to the feeder. Various groups formed on the basis of length and LF are listed below -

| Length of feeder | High LF<br>(Above 75%) | Mid LF<br>(40 – 74%) | Low LF<br>(Below 40%) |
|------------------|------------------------|----------------------|-----------------------|
| 0 to 0.99 km     | 4                      | 5                    | 4                     |
| 1 to 1.99 km     | 7                      | 6                    | 9                     |
| 2 to 2.99 km     | 10                     | 18                   | 15                    |
| 3 to 3.99 km     | 6                      | 14                   | 8                     |
| 4 to 4.99 km     | 6                      | 8                    | 6                     |
| 5 to 7 km        | 4                      | 7                    | 6                     |
| Above 7 km       | 3                      | 1                    | 6                     |

Table 4 - Grouping of 11 kV feeder samples (Numbers)

In subsequent chapters, the analysis of losses and cost benefit analysis has been classified into groups based on length of feeder and load factor. This will enable group-wise inferences and prompt further actions based on the findings therein.

## CHAPTER: 3 METHODOLOGY OF LOSS ANALYSIS

There are two methods for calculation of loss on 11 kV & 66 kV feeders. First is the conventional method, wherein both nominal current and resistance are derived. These values are then plugged into the  $I^2R$  formula to determine the losses. Second method makes use of popular load flow software called ETAP (Electrical Transient and Analysis Program). Single line diagrams of the sample feeders are fed as an input to ETAP and the load flow analysis, loss report etc. are obtained as an output of the software. Both methodologies are discussed in subsequent sections in detail.

### 11 kV Loss calculation methodology

First, the existing losses of 11 kV sample feeders has been determined. Both the conventional and software calculation process is discussed below -

#### Technical Loss calculation by conventional method

Loss due to connections of 11 kV consumers at individual 11 kV feeders is dependent upon 11 kV line losses (or  $I^2R$  losses) and 66 kV / 11 kV transformer losses at GETCO 66 / 11 kV substation from which the 11 kV line emanates. Hence, both for each sample, both line and transformer losses have been calculated as follows -

a) Calculation of 11 kV  $I^2R$  losses –

To calculate the  $I^2R$  losses, the load factor of individual 11 kV consumer needs to be evaluated first. Load Factor (LF) is defined as the ratio of the average demand over a period of time to the maximum demand within that period for the particular network. In other words, total actual consumption can be divided by hypothetical consumption at maximum permissible load for the consumer to find the load factor. Therefore, load factor of individual 11 kV consumer has been calculated as follows –

$$\text{Load Factor (LF)} = \frac{\text{Total Annual consumption in kWh}}{90\% \text{ of contract demand} \times 24 \text{ hours} \times 365 \text{ days}}$$

*Equation 1 - Calculation of Load Factor*

Since the peak load of all 11 kV feeders are available 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 -

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

*Equation 2 - Calculation of Loss Load Factor*

Now, to calculate the peak  $I^2R$  losses, Resistance (R) has been calculated as –

Resistance of 11 kV line (R) =  $3 \times r \times L$   
where  $r$  is the rated resistance of conductor in  $\Omega$  (ohm) /km and  $L$  is the length of feeder in km

Equation 3 - Resistance of 11 kV or 66 kV line

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

| Conductor / Cable type | Conductor / Cable size      | Standard AC resistance ( $\Omega$ /km) at 75°C <sup>3</sup> |
|------------------------|-----------------------------|-------------------------------------------------------------|
| AAAC Conductor         | Rabbit 55 mm <sup>2</sup>   | 0.7230                                                      |
| AAAC Conductor         | Dog 100 mm <sup>2</sup>     | 0.3955                                                      |
| ACSR Conductor         | Rabbit 55 mm <sup>2</sup>   | 0.7761                                                      |
| ACSR Conductor         | Dog 100 mm <sup>2</sup>     | 0.3924                                                      |
| ACSR Conductor         | Panther 200 mm <sup>2</sup> | 0.1706                                                      |
| XLPE Underground Cable | 185 mm <sup>2</sup>         | 0.2110                                                      |
| XLPE Underground Cable | 240 mm <sup>2</sup>         | 0.1620                                                      |
| XLPE Underground Cable | 630 mm <sup>2</sup>         | 0.0600                                                      |
| Aerial Bunched Cable   | 70 mm <sup>2</sup>          | 0.5670                                                      |
| Aerial Bunched Cable   | 90 mm <sup>2</sup>          | 0.4100                                                      |

Table 5 - Standard resistance by conductor / cable type

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

Peak power losses (P) =  $I^2 R$  (Watts)  
where  $I$  is the peak load of feeder in Amperes (A)

Equation 4 - Peak power losses of 11 kV feeder

Finally, total technical losses of the 11 kV feeder can be evaluated as follows –

$$\text{Total technical loss (L)} = \frac{\text{LLF} \times P \times 24 \text{ hours} \times 365 \text{ days}}{1000} \text{ kWh}$$

Equation 5 - Total technical loss on 11 kV feeder

<sup>3</sup> As per IS 398 (Part II) & IS 8130

b) Calculation of 66 kV / 11 kV transformer losses –

Maximum permissible full load losses of 66 kV / 11 kV power transformers are given below –

| Transformer rating   | Full load losses at 75°C (Copper loss + Stray loss) <sup>4</sup> |
|----------------------|------------------------------------------------------------------|
| 66 kV / 11 kV 5 MVA  | 27 kW                                                            |
| 66 kV / 11 kV 10 MVA | 38 kW                                                            |
| 66 kV / 11 kV 15 MVA | 56 kW                                                            |
| 66 kV / 11 kV 20 MVA | 73 kW                                                            |

Table 6 - Full load losses by power transformer rating

Therefore, to find the total transformer loss due to 11 kV consumer, the full load losses can be multiplied by loss load factor by the following equation –

$$\text{Total transformer loss (T)} = \text{Full load loss} \times \text{LLF} \times 24 \text{ hours} \times 365 \text{ days}$$

Equation 6 - Total transformer loss due to 11 kV consumer

Since all consumers in the sample fall between contract demand 2.5 MVA to 4 MVA, therefore, for the purpose of loss calculation, full load losses of 66 kV / 11 kV 5 MVA transformer have been considered proportionate to the capacity. For example, in case of 2.5 MVA consumer, half of the rates full load loss for 5 MVA power transformer have been considered.

Now the total technical loss on network due to 11 kV consumer can be easily calculated as sum of technical line loss (L) and total transformer loss (T) –

$$\text{Total Technical Loss (T}_{11}\text{)} = (\text{L} + \text{T}) \text{ kW}$$

Equation 7 - Total Technical Loss on 11 kV feeder

### Loss calculation based on ETAP results

In order to carry out analysis on ETAP software, firstly, SLD (Single Line Diagram) of the feeder must be made. An example of SLD is given below for reference -

<sup>4</sup> As per GETCO technical specifications of power transformers

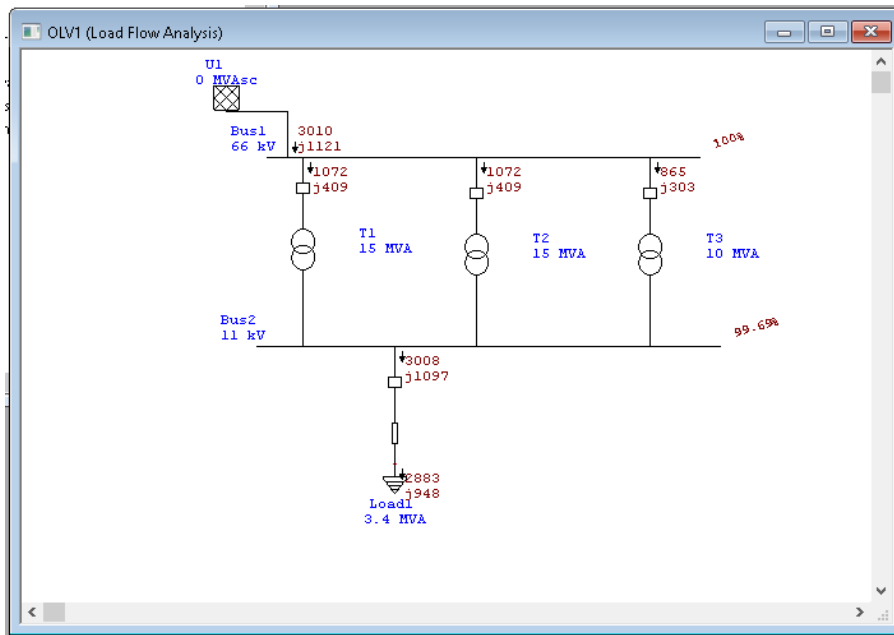


Figure 4 - Example of single line diagram on ETAP

Once SLD is correctly drawn out, Load flow report can be extracted which includes branch losses report. A screenshot of branch losses summary report is attached below for reference –

| Branch Losses Summary Report |                  |       |                  |        |        |       |               |      |                         |
|------------------------------|------------------|-------|------------------|--------|--------|-------|---------------|------|-------------------------|
| CKT / Branch<br>ID           | From-To Bus Flow |       | To-From Bus Flow |        | Losses |       | % Bus Voltage |      | Vd<br>% Drop<br>in Vmag |
|                              | MW               | Mvar  | MW               | Mvar   | kW     | kvar  | From          | To   |                         |
| T1                           | 1.072            | 0.409 | -1.072           | -0.400 | 0.4    | 8.8   | 100.0         | 99.7 | 0.31                    |
| T2                           | 1.072            | 0.409 | -1.072           | -0.400 | 0.4    | 8.8   | 100.0         | 99.7 | 0.31                    |
| T3                           | 0.865            | 0.303 | -0.864           | -0.296 | 0.5    | 7.0   | 100.0         | 99.7 | 0.31                    |
| Line1                        | 3.008            | 1.097 | -2.883           | -0.948 | 124.8  | 149.0 | 99.7          | 94.5 | 5.21                    |
|                              |                  |       |                  |        | 126.2  | 173.6 |               |      |                         |

Figure 5 - Example of branch losses summary report from ETAP

Now, the power losses given by ETAP can be multiplied by 8,760 (24 hours x 365 days) to get the total energy loss.

In the above example, total energy loss = 126.2 x 8760 = 11,05,512 kWh = 11.05 LU

## Validation of 11 kV Loss calculation

The 11 kV losses of each feeder has been compared with loss derived by Energy Audit cell of DISCOMs. Negligible difference in the loss shows the correctness of loss evaluation methodology by ETAP.

## 66 kV Loss calculation methodology

Once the technical losses at 11 kV level have been worked out for each feeder, the same feeder single line diagram has been re-drawn at 66 kV level and loss for the same network is evaluated at 66 kV level.

Current at 66 kV level shall be 1/6 times that of 11 kV level, therefore losses are significantly less than 11 kV.

However, it has to be kept in mind that existing 11 kV line infrastructure cannot be used in all cases. Since 66 kV lines requires H-frame type structure for propagation of lines, it poses issues of Right of Way (RoW). Although, ACSR Dog (100 mm<sup>2</sup>) or Panther (200 mm<sup>2</sup>) should be enough for the purpose of providing 66 kV connection to 2.5 MVA to 4 MVA consumers, in most cases underground cable has to be used to mitigate RoW issues. Thus, for the purpose of this study, 90:10 ratio has been used wherein 90% cases would require underground cable at 66 kV.

### Technical Loss calculation by conventional method

Calculation of Load Factor (LF), Loss Load Factor (LLF) and resistance shall remain same as given in equation 1, 2 and 3 for 11 kV voltage level. As stated above, current in 66 kV system shall be 1/6 of that in 11 kV system given by the following equation –

$$\text{Peak current at 66 kV level (I}_{66}\text{)} = I_{11} / 6 \text{ Amperes}$$

where  $I_{11}$  is the peak load of feeder at 11 kV level in Amperes (A)

Equation 8 - Peak current at 66 kV level

Now, the peak power losses at 66 kV can be calculated as follows –

$$\text{Peak power losses (P}_{66}\text{)} = I_{66}^2 R \text{ (Watts)}$$

where  $I_{66}$  is the peak load of 66 kV feeder in Amperes (A) as per equation 8

Equation 9 - Peak power losses of 66 kV feeder

Finally, total technical losses of the 66 kV feeder can be evaluated as follows –

$$\text{Total technical loss (T}_{66}\text{)} = \frac{\text{LLF} \times \text{P}_{66} \times 24 \text{ hours} \times 365 \text{ days}}{1000} \text{ kWh}$$

Equation 10 - Total technical loss on 66 kV feeder

### Loss calculation based on ETAP results

In order to carry out analysis on ETAP software, SLD (Single Line Diagram) of the hypothetical 66 kV feeder must be drawn. Once SLD is correctly drawn out, Load flow report can be extracted which includes branch losses report. A screenshot of branch losses summary report is attached below for reference –

| Branch Losses Summary Report |                  |        |                  |        |        |        |               |      |                         |
|------------------------------|------------------|--------|------------------|--------|--------|--------|---------------|------|-------------------------|
| CKT / Branch                 | From-To Bus Flow |        | To-From Bus Flow |        | Losses |        | % Bus Voltage |      | Vd<br>% Drop<br>in Vmag |
|                              | MW               | Mvar   | MW               | Mvar   | kW     | kvar   | From          | To   |                         |
| Line1                        | 0.451            | -0.202 | -0.450           | -0.148 | 0.4    | -349.7 | 100.0         | 99.9 | 0.09                    |
|                              |                  |        |                  |        | 0.4    | -349.7 |               |      |                         |

Figure 6 - Example of 66 kV branch losses summary on ETAP

As in case of 11kV, here too, the power losses given by ETAP can be multiplied by 8,760 (24 hours x 365 days) to get the total energy loss.

In the above example, total energy loss =  $0.4 \times 8760 = 3,504 \text{ kWh} = 0.03 \text{ LU}$

### Loss validation based on energy audit data

Since all DISCOMs conduct monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP. Few feeders have shown negative loss or very high quantum of loss in energy audit due to rotation of supply from different feeder as well as reading and accuracy bias. About 30 such feeders are found within the sample of 153 feeders.

## Calculating cost-benefit of 66 kV conversion

### Benefit due to 66 kV conversion

From equation 7 and 10 above, the difference in technical loss due to conversion from 11 kV to 66 kV system is –

$$\text{Difference in technical loss (T)} = T_{11} - T_{66} \text{ (units)}$$

*Equation 11 - Difference in technical loss due to conversion*

The average power purchase cost for Gujarat DISCOMs is Rs. 4.22 per unit<sup>5</sup>, out of which, variable cost is Rs. 2.12 per unit. Since the extent of benefit will only cover variable cost, therefore, the above-mentioned technical loss units can be simply multiplied by variable cost to find out annual financial gain due to conversion.

$$\text{Annual financial gain (A)} = T \times 2.12 \text{ (Rupees)}$$

*Equation 12 - Annual financial gain in Rupees*

### Capital Investment required by DISCOM for 66 kV conversion

**Investment<sup>6</sup> at 66 / 11 kV substation for extending 66 kV supply to HT consumer –**

|                                     |                |
|-------------------------------------|----------------|
| ≡ 66 kV bay creation                | = Rs. 0.38 Cr. |
| ≡ 66 kV circuit breaker             | = Rs. 0.04 Cr. |
| ≡ 66 kV bus extension with isolator | = Rs. 0.10 Cr. |

---

**Investment required at 66 / 11 kV substation = Rs. 0.52 Cr.**

**Per kilometre cost of 66 kV supply to HT consumer –**

|                                                                                                    |                     |
|----------------------------------------------------------------------------------------------------|---------------------|
| ≡ Overhead line on ACSR Dog 100 mm <sup>2</sup> conductor (single circuit) on H-frame (10 % cases) | = Rs. 0.15 Cr. / km |
|----------------------------------------------------------------------------------------------------|---------------------|

<sup>5</sup> Tariff Order for DISCOMs – FY 2018-19 (Table 7.1)

<sup>6</sup> All costs taken from GETCO

- OR -

XLPE underground cable 630 mm<sup>2</sup> (90 % cases) = Rs. 1.84 Cr. / km

Therefore, capital investment required by DISCOM can be obtained by multiplying line length with variable cost and adding the result with fixed cost as given below –

For 90 % cases (Alternative 1)

Capital investment (D1) = 0.52 + 1.84 x L (Rs. Cr.)

Where L = length of proposed 66 kV underground XLPE cable (ckt km)

Equation 13 - Cost of 66 kV conversion on 630 sq mm underground XLPE cable

For 10 % cases (Alternative 2)

Capital investment (D2) = 0.52 + 0.15 x L (Rs. Cr.)

Where L = length of proposed 66 kV line on Dog conductor (ckt km)

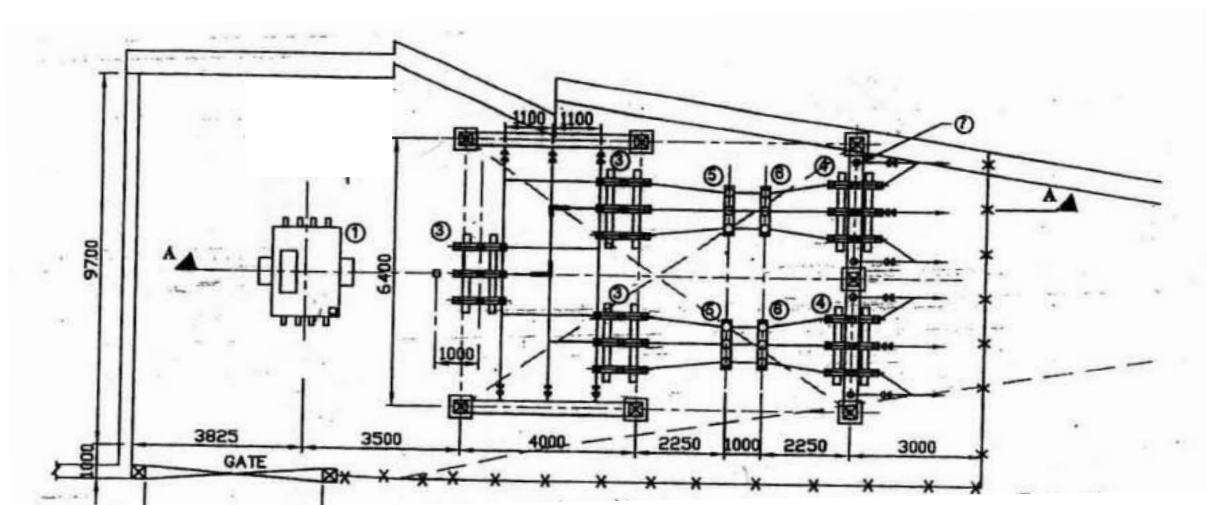
Equation 14 - Cost of 66 kV conversion on single circuit H-frame with ACSR dog conductor

## Capital Investment required by consumer for 66 kV conversion

At 66 kV supply, the consumer will be required to install the following -

- 66 kV bus with isolator
- 66 kV circuit breaker
- 66 kV transformer

A new yard with 66 kV bay will have to be created. Standard layout for the yard is given below –



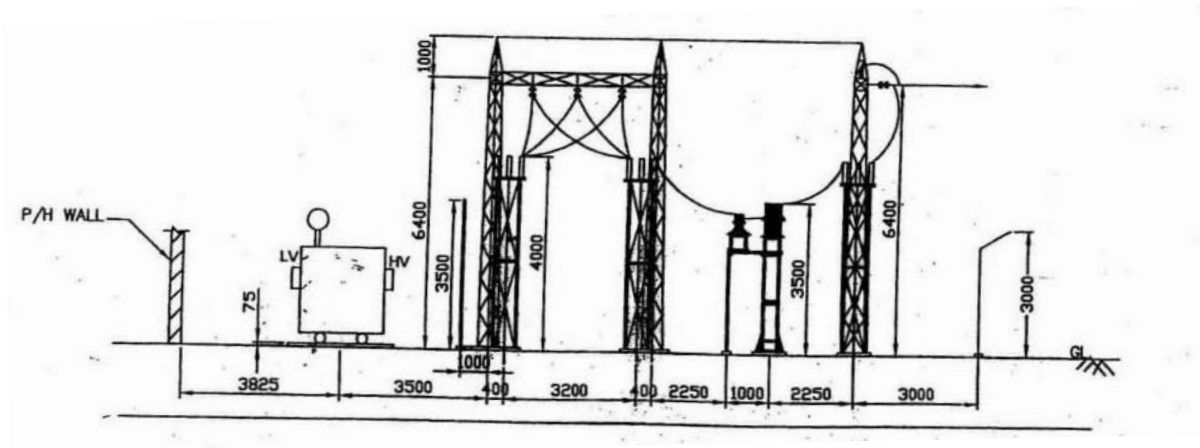


Figure 7 - Proposed layout of 66 kV yard at consumer end

This layout is suggested for futuristic purpose with provision for dual supply. However, consumer may choose single supply source. Total dimension of yard is – 9700 mm x 19825 mm ~ **194 sq. meters**.

|                                                |                                                           |
|------------------------------------------------|-----------------------------------------------------------|
| 66 kV bay creation                             | = Rs. 0.38 Cr.                                            |
| 66 kV circuit breaker                          | = Rs. 0.04 Cr.                                            |
| 66 kV bus extension with isolator              | = Rs. 0.10 Cr.                                            |
| Nominal cost of 66 transformer at consumer end | = Rs. 0.50 Cr.                                            |
| Land cost for yard                             | - As per GIDC allotment price for FY 2018-19 <sup>7</sup> |

Therefore, capital investment required from consumer side can be obtained as follows –

$$\text{Capital investment (C)} = 1 + 0.0000194 \times P \text{ (Rs. Cr.)}$$

z Where P = GIDC allotment price in consumer's area (Rs. Per sq. meter)

Equation 15 - 66 kV conversion cost required at consumer side

$$\text{Total Capital investment (B)} = C + D1 \text{ or } C + D2 \text{ (Rs. Cr.)}$$

z (depending on type of 66 kV line or cable used)

Equation 16 – Total cost of 66 kV conversion (DISCOM + consumer)

Now the payback period can be calculated by dividing the capital investment by financial gain as follows-

$$\text{Payback period (X)} = B / A \text{ (years)}$$

Equation 17 - Payback period calculation

<sup>7</sup> <http://gidc.gujarat.gov.in/pdf/allotment-price/Allotment-Price-2018-19.pdf>

## CHAPTER: 4 ANALYSIS OF SAMPLE FEEDERS - DGVCL

Details of sample feeders chosen for DGVCL area are as follows –

| Group        | Line Configuration                                                      | Feeder type | Numbers   |
|--------------|-------------------------------------------------------------------------|-------------|-----------|
| Group A      | 11 kV feeders on underground XLPE Cable (185 mm <sup>2</sup> )          | Express     | 4         |
| Group B      | 11 kV feeders on overhead ACSR Dog conductor (100 mm <sup>2</sup> )     | Express     | 15        |
| Group C      | 11 kV feeders on overhead ACSR Panther conductor (200 mm <sup>2</sup> ) | Express     | 1         |
|              | 11 kV feeders on overhead AAAC Dog conductor (100 mm <sup>2</sup> )     | Express     | 1         |
| <b>Total</b> |                                                                         |             | <b>21</b> |

Table 7 - Classification of sample feeders - DGVCL

Each of these feeder types are analysed in separate groups in subsequent sections of this chapter.

### Analysis of 11 kV feeders on 185 mm<sup>2</sup> XLPE cables – Group A

#### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name          | Length (ckt km) | Consumer Name    | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|----------------------|-----------------|------------------|-----------------------|----------------------------|-------------|
| 1      | 11kV Salasar         | 2.50            | Salasar Polytex  | 3000                  | 2,89,22,003                | 84%         |
| 2      | 11 kV Aarti Hydrogen | 2.50            | Aarti Industries | 2500                  | 14,80,902                  | 45%         |
| 3      | 11KV J.KORIN         | 0.30            | J.KORIN SPINNING | 2500                  | 1,43,91,700                | 74%         |
| 4      | 11 KV SUMILON FDR    | 0.25            | SUMILON IND Ltd  | 3000                  | 41,80,870                  | 62%         |

Table 8 - Basic details of feeders on Group A - DGCVL

#### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional I<sup>2</sup>R method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name          | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|----------------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | 11kV Salasar         | 155         | 0.737            | 1.583                           | 38,020                  |
| 2      | 11 kV Aarti Hydrogen | 35          | 0.252            | 1.583                           | 1,939                   |
| 3      | 11KV J.KORIN         | 125         | 0.590            | 0.190                           | 2,967                   |
| 4      | 11 KV SUMILON FDR    | 156         | 0.436            | 0.158                           | 3,851                   |

Table 9 - Calculation of peak power losses in 11 kV feeders on Group A - DGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name          | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|----------------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11kV Salasar         | 2,45,461        | 1,04,590               | 3,50,052         | 1.2%               |
| 2      | 11 kV Aarti Hydrogen | 4,279           | 29,802                 | 34,081           | 2.3%               |
| 3      | 11KV J.KORIN         | 15,345          | 69,816                 | 85,161           | 0.6%               |
| 4      | 11 KV SUMILON FDR    | 14,716          | 61,904                 | 76,621           | 1.8%               |

Table 10 - Technical loss calculation at 11 kV level in feeders on Group A - DGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name          | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|----------------------|------------------------------|-------------------------------|--------------------|
| 1      | 11kV Salasar         | 49.2                         | 4,30,992                      | 1.5%               |
| 2      | 11 kV Aarti Hydrogen | 3.7                          | 32,412                        | 2.2%               |
| 3      | 11KV J.KORIN         | 8.6                          | 75,336                        | 0.5%               |
| 4      | 11 KV SUMILON FDR    | 7                            | 61,320                        | 1.5%               |

Table 11 - 11 kV loss results from ETAP software in feeders on Group A - DGCVL

## Comparison of ETAP results with DISCOM energy audit

Since DGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name          | Loss calculated by ETAP (kWh) | Technical Loss by ETAP (%) | Loss by DISCOM energy audit (kWh) | DISCOM EA loss (%) |
|--------|----------------------|-------------------------------|----------------------------|-----------------------------------|--------------------|
| 1      | 11kV Salasar         | 4,30,992                      | 1.5%                       | 2,49,884                          | 0.9%               |
| 2      | 11 kV Aarti Hydrogen | 32,412                        | 2.2%                       | 29,257                            | 2.0%               |
| 3      | 11KV J.KORIN         | 75,336                        | 0.5%                       | -1,15,579                         | 0.8%               |

| Sl No. | Feeder Name       | Loss calculated by ETAP (kWh) | Technical Loss by ETAP (%) | Loss by DISCOM energy audit (kWh) | DISCOM EA loss (%) |
|--------|-------------------|-------------------------------|----------------------------|-----------------------------------|--------------------|
| 4      | 11 KV SUMILON FDR | 61,320                        | 1.5%                       | 67,280                            | 1.6%               |

Table 12 - Comparison of ETAP results with energy audit results

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below -

| Sl No. | Feeder Name          | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|----------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11kV Salasar         | 1,939                 | 0.01%          | 2,628                   | 0.01%                      |
| 2      | 11 kV Aarti Hydrogen | 537                   | 0.00%          | 876                     | 0.01%                      |
| 3      | 11KV J.KORIN         | 121                   | 0.00%          | -                       | 0.00%                      |
| 4      | 11 KV SUMILON FDR    | 116                   | 0.00%          | -                       | 0.00%                      |

Table 13 - Loss calculation at 66 kV level in feeders on Group A - DGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name          | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|----------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | 11kV Salasar         | 4,30,992                            | 2,628                   | 2.12                                | 0.09                    |
| 2      | 11 kV Aarti Hydrogen | 32,412                              | 876                     | 2.12                                | 0.01                    |
| 3      | 11KV J.KORIN         | 75,336                              | -                       | 2.12                                | 0.02                    |
| 4      | 11 KV SUMILON FDR    | 61,320                              | -                       | 2.12                                | 0.01                    |

Table 14 - Annual saving due to conversion of feeders on Group A - DGCVL into 66 kV

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name          | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|----------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11kV Salasar         | 4,430                                | 1.09                                | 5.12                              | 6.21                                        |
| 2      | 11 kV Aarti Hydrogen | 1,250                                | 1.02                                | 5.12                              | 6.14                                        |
| 3      | 11KV J.KORIN         | 2,420                                | 1.05                                | 1.07                              | 2.12                                        |
| 4      | 11 KV SUMILON FDR    | 4,430                                | 1.09                                | 0.98                              | 2.07                                        |

Table 15 - Conversion cost for supply at 66kV level for feeders on Group A - DGCVL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name          | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|----------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11kV Salasar         | 6.21                                        | 0.09                    | 68                     |
| 2      | 11 kV Aarti Hydrogen | 6.14                                        | 0.01                    | 133                    |
| 3      | 11KV J.KORIN         | 2.12                                        | 0.02                    | 159                    |
| 4      | 11 KV SUMILON FDR    | 2.07                                        | 0.01                    | 919                    |

Table 16 - Payback period for conversion to 66 kV for feeders on Group A - DGCVL

# Analysis of 11 kV feeders on 100 mm<sup>2</sup> ACSR Dog conductors – Group B

## Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name        | Length (ckt km) | Consumer Name                     | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|--------------------|-----------------|-----------------------------------|-----------------------|----------------------------|-------------|
| 1      | 11KV Sumeet        | 1.01            | M/S SUMEET POLY POWER LTD         | 4000                  | 2,59,38,858                | 92%         |
| 2      | ARTI ORGANICS      | 0.28            | ARTI INDUSTRIES LTD               | 2500                  | 1,10,00,880                | 89%         |
| 3      | 11 KV SHABNAM FDR  | 8.18            | M/S SHABNAM PETROFILS             | 3600                  | 14,60,27,699               | 80%         |
| 4      | 11 KV Tamanna      | 0.53            | TAMANNA INTERNATIONALS            | 4000                  | 2,53,73,421                | 79%         |
| 5      | 11KV Chemical zone | 4.80            | M/S HEMANI INDUSTRIES LTD         | 3000                  | 2,34,32,554                | 77%         |
| 6      | SABERO ORGANICS    | 3.10            | Coromandel International Ltd      | 4000                  | 67,72,215                  | 69%         |
| 7      | 11 KV SANJAY       | 4.30            | M/S SAANIKA INDUSTRIES            | 3000                  | 5,86,19,043                | 69%         |
| 8      | 11 KV DIVYA        | 3.50            | M/S.PRACHI MITTAL CREATIONS       | 2500                  | 2,27,16,375                | 67%         |
| 9      | 11 KV GULSHAN      | 3.30            | S.KUMAR NATIONWIDE LTD.           | 2800                  | 87,18,928                  | 58%         |
| 10     | 11 KV AARTI EXP    | 3.00            | ARTI INDUSTRIES LTD.              | 3500                  | 75,75,461                  | 57%         |
| 11     | BEST P. MILL (OLD) | 0.80            | BEST PAPER MILLS PVT. LTD.        | 3000                  | 72,16,574                  | 53%         |
| 12     | 11 KV L&T          | 5.24            | LARSEN & TOUBRO LTD.              | 3400                  | 1,44,57,690                | 53%         |
| 13     | 11 KV GUJRAT GAS   | 1.84            | GULSHAN POLYOLS LTD.              | 2800                  | 2,89,50,759                | 48%         |
| 14     | 11 KV NIKO COSTAL  | 5.50            | LARSEN & TOUBRO MHI. BOILAR PLANT | 2500                  | 1,23,08,452                | 41%         |
| 15     | 11 kV Jay India    | 2.30            | Jai India Alloys                  | 4000                  | 4,49,479                   | 19%         |

Table 17 - Basic details of feeders on Group B – DGCVL

## Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional I<sup>2</sup>R method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name        | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|--------------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | 11KV Sumeet        | 206         | 0.868            | 1.189                           | 50,455                  |
| 2      | ARTI ORGANICS      | 130         | 0.812            | 0.324                           | 5,471                   |
| 3      | 11 KV SHABNAM FDR  | 166         | 0.674            | 9.629                           | 2,65,350                |
| 4      | 11 KV Tamanna      | 125         | 0.656            | 0.624                           | 9,749                   |
| 5      | 11KV Chemical zone | 76          | 0.623            | 5.651                           | 32,638                  |
| 6      | SABERO ORGANICS    | 41          | 0.518            | 3.650                           | 6,136                   |
| 7      | 11 KV SANJAY       | 226         | 0.517            | 5.062                           | 2,58,545                |
| 8      | 11 KV DIVYA        | 97          | 0.493            | 4.120                           | 38,767                  |
| 9      | 11 KV GULSHAN      | 45          | 0.385            | 3.885                           | 7,867                   |
| 10     | 11 KV AARTI EXP    | 90          | 0.374            | 3.532                           | 28,606                  |
| 11     | BEST P. MILL (OLD) | 96          | 0.333            | 0.938                           | 8,647                   |
| 12     | 11 KV L&T          | 85          | 0.333            | 6.169                           | 44,568                  |
| 13     | 11 KV GUJRAT GAS   | 174         | 0.279            | 2.166                           | 65,579                  |
| 14     | 11 KV NIKO COSTAL  | 124         | 0.219            | 6.475                           | 99,553                  |
| 15     | 11 kV Jay India    | 37          | 0.068            | 2.708                           | 3,707                   |

Table 18 - Calculation of peak power losses at 11 kV in feeders on Group B - DGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name        | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|--------------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11KV Sumeet        | 3,83,428        | 1,64,147               | 5,47,575         | 2.1%               |
| 2      | ARTI ORGANICS      | 38,901          | 95,989                 | 1,34,890         | 1.2%               |
| 3      | 11 KV SHABNAM FDR  | 15,65,702       | 1,14,706               | 16,80,408        | 1.2%               |
| 4      | 11 KV Tamanna      | 55,992          | 1,24,061               | 1,80,053         | 0.7%               |
| 5      | 11KV Chemical zone | 1,78,051        | 88,377                 | 2,66,429         | 1.1%               |
| 6      | SABERO ORGANICS    | 27,822          | 97,932                 | 1,25,754         | 1.9%               |
| 7      | 11 KV SANJAY       | 11,71,696       | 73,417                 | 12,45,113        | 2.1%               |
| 8      | 11 KV DIVYA        | 1,67,463        | 58,316                 | 2,25,779         | 1.0%               |
| 9      | 11 KV GULSHAN      | 26,539          | 51,010                 | 77,549           | 0.9%               |
| 10     | 11 KV AARTI EXP    | 93,700          | 61,908                 | 1,55,608         | 2.1%               |
| 11     | BEST P. MILL (OLD) | 25,261          | 47,327                 | 72,587           | 1.0%               |
| 12     | 11 KV L&T          | 1,30,141        | 53,613                 | 1,83,754         | 1.3%               |
| 13     | 11 KV GUJRAT GAS   | 1,60,139        | 36,922                 | 1,97,060         | 0.7%               |

| Sl No. | Feeder Name       | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-------------------|-----------------|------------------------|------------------|--------------------|
| 14     | 11 KV NIKO COSTAL | 1,90,699        | 25,860                 | 2,16,558         | 1.8%               |
| 15     | 11 kV Jay India   | 2,216           | 12,914                 | 15,130           | 3.4%               |

Table 19 - Technical loss calculation at 11 kV level for feeders on Group B - DGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name        | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|--------------------|------------------------------|-------------------------------|--------------------|
| 1      | 11KV Sumeet        | 45.7                         | 4,00,332                      | 1.5%               |
| 2      | ARTI ORGANICS      | 24.3                         | 2,12,868                      | 1.9%               |
| 3      | 11 KV SHABNAM FDR  | 187.5                        | 16,42,500                     | 1.1%               |
| 4      | 11 KV Tamanna      | 32.1                         | 2,81,196                      | 1.1%               |
| 5      | 11KV Chemical zone | 27.2                         | 2,38,272                      | 1.0%               |
| 6      | SABERO ORGANICS    | 11.9                         | 1,04,244                      | 1.5%               |
| 7      | 11 KV SANJAY       | 122.6                        | 10,73,976                     | 1.8%               |
| 8      | 11 KV DIVYA        | 35.6                         | 3,11,856                      | 1.4%               |
| 9      | 11 KV GULSHAN      | 7.2                          | 63,072                        | 0.7%               |
| 10     | 11 KV AARTI EXP    | 14.6                         | 1,27,896                      | 1.7%               |
| 11     | BEST P. MILL (OLD) | 6.9                          | 60,444                        | 0.8%               |
| 12     | 11 KV L&T          | 19.6                         | 1,71,696                      | 1.2%               |
| 13     | 11 KV GUJRAT GAS   | 12                           | 1,05,120                      | 0.4%               |
| 14     | 11 KV NIKO COSTAL  | 19.4                         | 1,69,944                      | 1.4%               |
| 15     | 11 kV Jay India    | 2.1                          | 18,396                        | 4.1%               |

Table 20 - 11 kV loss results from ETAP software for feeders on Group B - DGCVL

### Comparison of loss by ETAP and DISCOM energy audit

Since DGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name         | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|---------------------|-----------------|---------------|-------------------------|-----------------------|
| 1      | 11KV Sumeet         | 4,00,332        | 1.5%          | 3,02,180                | 1.2%                  |
| 2      | ARTI ORGANICS       | 2,12,868        | 1.9%          | 2,34,690                | 2.1%                  |
| 3      | 11 KV SHABNAM FDR   | 16,42,500       | 1.1%          | 15,96,537               | 1.1%                  |
| 4      | 11 KV Tamanna       | 2,81,196        | 1.1%          | 2,52,541                | 1.0%                  |
| 5      | 11KV Chemical zone* | 2,38,272        | 1.0%          | 2,24,124                | 1.0%                  |
| 6      | SABERO ORGANICS     | 1,04,244        | 1.5%          | 67,610                  | 1.0%                  |
| 7      | 11 KV SANJAY        | 10,73,976       | 1.8%          | 9,30,536                | 1.6%                  |

| Sl No. | Feeder Name        | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|--------------------|-----------------|---------------|-------------------------|-----------------------|
| 8      | 11 KV DIVYA        | 3,11,856        | 1.4%          | -3,97,403               | 1.7%                  |
| 9      | 11 KV GULSHAN*     | 63,072          | 0.7%          | 93,526                  | 1.1%                  |
| 10     | 11 KV AARTI EXP    | 1,27,896        | 1.7%          | 74,420                  | 1.0%                  |
| 11     | BEST P. MILL (OLD) | 60,444          | 0.8%          | -49,880                 | 0.7%                  |
| 12     | 11 KV L&T          | 1,71,696        | 1.2%          | -19,178                 | 2.0%                  |
| 13     | 11 KV GUJRAT GAS   | 1,05,120        | 0.4%          | -4,82,602               | 1.7%                  |
| 14     | 11 KV NIKO COSTAL  | 1,69,944        | 1.4%          | 2,40,846                | 2.0%                  |
| 15     | 11 kV Jay India    | 18,396          | 4.1%          | -8,850                  | 2.0%                  |

Table 21 - Comparison of ETAP results with DISCOM energy audit

\* Consumers assumed to be supplied on 100 mm<sup>2</sup> Dog conductor overhead line

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name         | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|---------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11KV Sumeet         | 1,629                 | 0.05%          | 2,628                   | 0.05%                      |
| 2      | ARTI ORGANICS       | 165                   | 0.03%          | -                       | 0.00%                      |
| 3      | 11 KV SHABNAM FDR   | 6,650                 | 0.01%          | 11,388                  | 0.02%                      |
| 4      | 11 KV Tamanna       | 238                   | 0.17%          | 876                     | 0.11%                      |
| 5      | 11KV Chemical zone* | 4,946                 | 0.11%          | 20,148                  | 0.07%                      |
| 6      | SABERO ORGANICS     | 118                   | 0.01%          | 3,504                   | 0.02%                      |
| 7      | 11 KV SANJAY        | 4,977                 | 0.01%          | 2,628                   | 0.01%                      |
| 8      | 11 KV DIVYA         | 711                   | 0.01%          | -                       | 0.00%                      |
| 9      | 11 KV GULSHAN*      | 737                   | 0.01%          | 12,264                  | 0.01%                      |
| 10     | 11 KV AARTI EXP     | 398                   | 0.01%          | 876                     | 0.00%                      |
| 11     | BEST P. MILL (OLD)  | 107                   | 0.01%          | 876                     | 0.01%                      |
| 12     | 11 KV L&T           | 553                   | 0.01%          | 2,628                   | 0.00%                      |
| 13     | 11 KV GUJRAT GAS    | 680                   | 0.00%          | -                       | 0.00%                      |
| 14     | 11 KV NIKO COSTAL   | 810                   | 0.00%          | 876                     | 0.00%                      |
| 15     | 11 kV Jay India     | 9                     | 0.00%          | -                       | 0.01%                      |

Table 22 - Loss calculation at 66 kV level for feeders on Group B – DGCVL

\* Consumers assumed to be supplied on 100 mm<sup>2</sup> Dog conductor overhead line

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name         | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|---------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | 11KV Sumeet         | 4,00,332                            | 2,628                   | 2.12                                | 0.08                    |
| 2      | ARTI ORGANICS       | 2,12,868                            | -                       | 2.12                                | 0.05                    |
| 3      | 11 KV SHABNAM FDR   | 16,42,500                           | 11,388                  | 2.12                                | 0.35                    |
| 4      | 11 KV Tamanna       | 2,81,196                            | 876                     | 2.12                                | 0.06                    |
| 5      | 11KV Chemical zone* | 2,38,272                            | 20,148                  | 2.12                                | 0.05                    |
| 6      | SABERO ORGANICS     | 1,04,244                            | 3,504                   | 2.12                                | 0.02                    |
| 7      | 11 KV SANJAY        | 10,73,976                           | 2,628                   | 2.12                                | 0.23                    |
| 8      | 11 KV DIVYA         | 3,11,856                            | -                       | 2.12                                | 0.07                    |
| 9      | 11 KV GULSHAN*      | 63,072                              | 12,264                  | 2.12                                | 0.01                    |
| 10     | 11 KV AARTI EXP     | 1,27,896                            | 876                     | 2.12                                | 0.03                    |
| 11     | BEST P. MILL (OLD)  | 60,444                              | 876                     | 2.12                                | 0.01                    |
| 12     | 11 KV L&T           | 1,71,696                            | 2,628                   | 2.12                                | 0.04                    |
| 13     | 11 KV GUJRAT GAS    | 1,05,120                            | -                       | 2.12                                | 0.02                    |
| 14     | 11 KV NIKO COSTAL   | 1,69,944                            | 876                     | 2.12                                | 0.04                    |
| 15     | 11 kV Jay India     | 18,396                              | -                       | 2.12                                | 0.00                    |

Table 23 - Annual saving due to conversion into 66 kV for feeders on Group B – DGCVL

\* Consumers assumed to be supplied on 100 mm<sup>2</sup> Dog conductor overhead line

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name         | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|---------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11KV Sumeet         | 100                                  | 1.00                                | 2.38                              | 3.38                                        |
| 2      | ARTI ORGANICS       | 4,160                                | 1.08                                | 1.03                              | 2.11                                        |
| 3      | 11 KV SHABNAM FDR   | 5,930                                | 1.12                                | 15.57                             | 16.69                                       |
| 4      | 11 KV Tamanna       | 4,430                                | 1.09                                | 1.50                              | 2.58                                        |
| 5      | 11KV Chemical zone* | 100                                  | 1.00                                | 1.24                              | 2.24                                        |

| Sl No. | Feeder Name        | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|--------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 6      | SABERO ORGANICS    | 1,250                                | 1.02                                | 6.23                              | 7.25                                        |
| 7      | 11 KV SANJAY       | 180                                  | 1.00                                | 8.43                              | 9.44                                        |
| 8      | 11 KV DIVYA        | 4,430                                | 1.09                                | 6.96                              | 8.05                                        |
| 9      | 11 KV GULSHAN*     | 1,250                                | 1.02                                | 1.02                              | 2.04                                        |
| 10     | 11 KV AARTI EXP    | 1,250                                | 1.02                                | 6.04                              | 7.06                                        |
| 11     | BEST P. MILL (OLD) | 4,160                                | 1.08                                | 1.99                              | 3.07                                        |
| 12     | 11 KV L&T          | 640                                  | 1.01                                | 10.16                             | 11.17                                       |
| 13     | 11 KV GUJRAT GAS   | 1,250                                | 1.02                                | 3.91                              | 4.93                                        |
| 14     | 11 KV NIKO COSTAL  | 3,210                                | 1.06                                | 10.64                             | 11.70                                       |
| 15     | 11 kV Jay India    | 420                                  | 1.01                                | 4.75                              | 5.76                                        |

Table 24 - Conversion cost for supply at 66kV level for feeders on Group B – DGCVL

\* Consumers assumed to be supplied on 100 mm<sup>2</sup> Dog conductor overhead line

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name         | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|---------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11KV Sumeet         | 3.38                                        | 0.08                    | 40                     |
| 2      | ARTI ORGANICS       | 2.11                                        | 0.05                    | 47                     |
| 3      | 11 KV SHABNAM FDR   | 16.69                                       | 0.35                    | 48                     |
| 4      | 11 KV Tamanna       | 2.58                                        | 0.06                    | 43                     |
| 5      | 11KV Chemical zone* | 2.24                                        | 0.05                    | 48                     |
| 6      | SABERO ORGANICS     | 7.25                                        | 0.02                    | 339                    |
| 7      | 11 KV SANJAY        | 9.44                                        | 0.23                    | 42                     |
| 8      | 11 KV DIVYA         | 8.05                                        | 0.07                    | 122                    |
| 9      | 11 KV GULSHAN*      | 2.04                                        | 0.01                    | 189                    |
| 10     | 11 KV AARTI EXP     | 7.06                                        | 0.03                    | 262                    |
| 11     | BEST P. MILL (OLD)  | 3.07                                        | 0.01                    | 243                    |
| 12     | 11 KV L&T           | 11.17                                       | 0.04                    | 312                    |
| 13     | 11 KV GUJRAT GAS    | 4.93                                        | 0.02                    | 221                    |
| 14     | 11 KV NIKO COSTAL   | 11.70                                       | 0.04                    | 326                    |
| 15     | 11 kV Jay India     | 5.76                                        | 0.00                    | 1,477                  |

Table 25 - Payback period for conversion to 66 kV for feeders on Group B - DGCVL

## Analysis of 11 kV feeders on 200 mm<sup>2</sup> ACSR Panther & 100 mm<sup>2</sup> AAAC Dog conductors – Group C

### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name      | Length (ckt km) | Consumer Name    | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|------------------|-----------------|------------------|-----------------------|----------------------------|-------------|
| 1      | SUMAN PAPER MILL | 0.86            | N R AGARWAL IND  | 2500                  | 17,26,814                  | 42%         |
| 2      | CALIBRE CHEMICAL | 0.68            | CALIBRE CHEMICAL | 4000                  | 2,92,30,258                | 63%         |

Table 26 - Basic details of feeders on Group C - DGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional I<sup>2</sup>R method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name      | Load (Amps) | Loss Load Factor | Resistance of line (Ω) | Peak Power Loss (Watts) |
|--------|------------------|-------------|------------------|------------------------|-------------------------|
| 1      | SUMAN PAPER MILL | 22          | 0.225            | 1.020                  | 494                     |
| 2      | CALIBRE CHEMICAL | 176         | 0.445            | 0.348                  | 10,780                  |

Table 27 - Calculation of peak power losses at 11 kV for feeders on Group C - DGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name      | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|------------------|-----------------|------------------------|------------------|--------------------|
| 1      | SUMAN PAPER MILL | 974             | 26,623                 | 27,597           | 1.6%               |
| 2      | CALIBRE CHEMICAL | 42,025          | 84,202                 | 1,26,227         | 0.4%               |

Table 28 - Technical loss calculation at 11 kV level for feeders on Group C - DGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name      | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|------------------|------------------------------|-------------------------------|--------------------|
| 1      | SUMAN PAPER MILL | 2.1                          | 18,396                        | 1.1%               |
| 2      | CALIBRE CHEMICAL | 16.1                         | 1,41,036                      | 0.5%               |

Table 29 - 11 kV loss results from ETAP software for feeders on Group C - DGCVL

### Comparison of ETAP results with energy audit

Since DGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name      | ETAP Loss (kWh) | ETAP (%) | EA loss (kWh) | EA Loss (%) |
|--------|------------------|-----------------|----------|---------------|-------------|
| 1      | SUMAN PAPER MILL | 18,396          | 1.1%     | -2,69,240     | 0.9%        |
| 2      | CALIBRE CHEMICAL | 1,41,036        | 0.5%     | -16,150       | 0.9%        |

Table 30 - Comparison of ETAP results with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name      | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | SUMAN PAPER MILL | 4                     | 0.00%          | 876                     | 0.01%                      |
| 2      | CALIBRE CHEMICAL | 411                   | 0.00%          | 876                     | 0.00%                      |

Table 31 - Loss calculation at 66 kV level for feeders on Group C - DGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name      | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving ((Rs. Cr.) |
|--------|------------------|-------------------------------------|-------------------------|-------------------------------------|--------------------------|
| 1      | SUMAN PAPER MILL | 18,396                              | 876                     | 2.12                                | 0.03                     |
| 2      | CALIBRE CHEMICAL | 1,41,036                            | 876                     | 2.12                                | 0.00                     |

Table 32 - Annual saving due to conversion into 66 kV for feeders on Group C - DGCVL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name      | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | SUMAN PAPER MILL | 1,300                                | 1.03                                | 1.77                              | 2.80                                        |
| 2      | CALIBRE CHEMICAL | 4,160                                | 1.08                                | 2.10                              | 3.18                                        |

Table 33 - Conversion cost for supply at 66kV level for feeders on Group C - DGCVL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name      | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | SUMAN PAPER MILL | 2.80                                        | 0.03                    | 94                     |
| 2      | CALIBRE CHEMICAL | 3.18                                        | 0.00                    | 857                    |

Table 34 - Payback period for conversion to 66 kV for feeders on Group C – DGCVL

## CHAPTER: 5 ANALYSIS OF SAMPLE FEEDERS - MGVCCL

Details of sample feeders chosen for MGVCCL area are as follows –

| Group        | Configuration                                                         | Feeder type | Numbers   |
|--------------|-----------------------------------------------------------------------|-------------|-----------|
| Group A      | 11 kV feeders on underground XLPE Cable (185 mm <sup>2</sup> )        | Express     | 15        |
|              | 11 kV feeders on underground XLPE Cable (240 mm <sup>2</sup> )        | Express     | 2         |
| Group B      | 11 kV feeders on overhead ACSR Dog conductor (100 mm <sup>2</sup> )   | Express     | 8         |
|              | 11 kV feeders on overhead AAAC Dog conductor (100 mm <sup>2</sup> )   | Express     | 4         |
| Group C      | 11 kV feeders on overhead ACSR Rabbit conductor (55 mm <sup>2</sup> ) | Express     | 4         |
|              | 11 kV feeders on overhead AAAC Rabbit conductor (55 mm <sup>2</sup> ) | Express     | 3         |
| Group D      | 11 kV feeders on overhead AB Cable (70 mm <sup>2</sup> )              | Express     | 4         |
|              | 11 kV feeders on overhead AB Cable (95 mm <sup>2</sup> )              | Express     | 1         |
| <b>Total</b> |                                                                       |             | <b>41</b> |

Table 35 - Classification of sample feeders - MGVCCL

Each of these feeder types are analysed in separate groups in subsequent sections of this chapter.

### Analysis of 11 kV feeders on 185 mm<sup>2</sup> & 240 mm<sup>2</sup> XLPE cables – Group A

#### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name        | Length (ckt km) | Consumer Name              | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|--------------------|-----------------|----------------------------|-----------------------|----------------------------|-------------|
| 1      | Bharat Oman        | 3.55            | BHARAT OMAN REFINERIES     | 3000                  | 1,96,63,400                | 91%         |
| 2      | 11 KV BODAL        | 5.57            | M/S BODAL CHEMICAL         | 3950                  | 2,79,36,319                | 88%         |
| 3      | Agrawal Mittal Exp | 1.00            | M/S AGRAWAL MITTAL CONCAST | 4000                  | 2,72,67,588                | 86%         |
| 4      | 11 KV ABS PLASTIC  | 1.02            | M/S INEOS STYROLUTION      | 2400                  | 1,76,12,280                | 81%         |
| 5      | Lupin              | 4.72            | M/S. Lupin Ltd.            | 3500                  | 2,15,79,000                | 77%         |
| 6      | 11 kV Baroda Dairy | 2.10            | Baroda Dist Coop           | 2400                  | 1,46,35,039                | 77%         |

| Sl No. | Feeder Name         | Length (ckt km) | Consumer Name                    | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|---------------------|-----------------|----------------------------------|-----------------------|----------------------------|-------------|
| 7      | 11 KV ABS BAYER     | 4.40            | M/S INEOS STYROLUTION            | 2800                  | 1,66,16,520                | 75%         |
| 8      | 11 KV TS-2          | 3.18            | TRANSPEK-SILOX INDUSTRY PVT LTD. | 2250                  | 74,80,040                  | 58%         |
| 9      | 11 KV RR KABEL      | 4.30            | M/S R.R.KABLE LTD                | 3990                  | 1,57,44,000                | 49%         |
| 10     | 11 kV ONGC-2        | 2.30            | DGM, ONGC                        | 2200                  | 79,34,360                  | 45%         |
| 11     | L&T-2               | 3.08            | M/S LARSEN & TOURBO LTD.         | 2400                  | 71,36,040                  | 44%         |
| 12     | Polysteel           | 3.40            | M-S POLYCAB CABLES - II)         | 2500                  | 1,74,94,020                | 43%         |
| 13     | 11 kV Himgiri       | 2.00            | Himgiri Castings                 | 3500                  | 1,14,27,960                | 41%         |
| 14     | 11KV Trupti Casting | 1.11            | M/S.ELECON ENGINEERING           | 4000                  | 1,40,21,970                | 39%         |
| 15     | 11 kV Kalali        | 2.20            | Transpek Silox                   | 3250                  | 2,09,46,220                | 29%         |
| 16     | 11 KV OM IGNOTS     | 1.70            | M/S OM INGOTS                    | 4000                  | 84,72,309                  | 27%         |
| 17     | 11KV L&T            | 3.00            | M/S. Larsen & Toubro Ltd.        | 3400                  | 83,84,770                  | 26%         |

Table 36 - Basic details of feeders on Group A - MGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional  $I^2R$  method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name        | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|--------------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | Bharat Oman        | 140         | 0.844            | 2.244                           | 43,982                  |
| 2      | 11 KV BODAL        | 160         | 0.791            | 2.707                           | 69,300                  |
| 3      | Agrawal Mittal Exp | 216         | 0.763            | 0.633                           | 29,533                  |
| 4      | 11 KV ABS PLASTIC  | 127         | 0.688            | 0.646                           | 10,414                  |
| 5      | Lupin              | 156         | 0.622            | 2.988                           | 72,710                  |
| 6      | 11 kV Baroda Dairy | 128         | 0.621            | 1.329                           | 21,779                  |
| 7      | 11 KV ABS BAYER    | 135         | 0.602            | 2.785                           | 50,760                  |
| 8      | 11 KV TS-2         | 56          | 0.385            | 2.010                           | 6,303                   |
| 9      | 11 KV RR KABEL     | 198         | 0.288            | 2.722                           | 1,06,709                |
| 10     | 11 kV ONGC-2       | 72          | 0.254            | 1.456                           | 7,547                   |

| Sl No. | Feeder Name         | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|---------------------|-------------|------------------|---------------------------------|-------------------------|
| 11     | L&T-2               | 85          | 0.245            | 1.950                           | 14,086                  |
| 12     | Polysteel           | 204         | 0.230            | 2.152                           | 89,566                  |
| 13     | 11 kV Himgiri       | 162         | 0.220            | 1.266                           | 33,225                  |
| 14     | 11KV Trupti Casting | 191         | 0.196            | 0.541                           | 19,733                  |
| 15     | 11 kV Kalali        | 164         | 0.126            | 1.393                           | 37,455                  |
| 16     | 11 KV OM IGNOTS     | 193         | 0.111            | 1.076                           | 40,084                  |
| 17     | 11KV L&T            | 114         | 0.107            | 1.899                           | 24,679                  |

Table 37 - Calculation of peak power losses at 11 kV for feeders on Group A - MGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name         | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|---------------------|-----------------|------------------------|------------------|--------------------|
| 1      | Bharat Oman         | 3,25,364        | 1,19,842               | 4,45,206         | 2.3%               |
| 2      | 11 KV BODAL         | 4,79,988        | 1,47,737               | 6,27,726         | 2.2%               |
| 3      | Agrawal Mittal Exp  | 1,97,291        | 1,44,294               | 3,41,585         | 1.3%               |
| 4      | 11 KV ABS PLASTIC   | 62,789          | 78,141                 | 1,40,930         | 0.8%               |
| 5      | Lupin               | 3,96,125        | 1,02,967               | 4,99,093         | 2.3%               |
| 6      | 11 kV Baroda Dairy  | 1,18,550        | 70,545                 | 1,89,095         | 1.3%               |
| 7      | 11 KV ABS BAYER     | 2,67,632        | 79,720                 | 3,47,351         | 2.1%               |
| 8      | 11 KV TS-2          | 21,263          | 40,990                 | 62,253           | 0.8%               |
| 9      | 11 KV RR KABEL      | 2,68,983        | 54,311                 | 3,23,295         | 2.1%               |
| 10     | 11 kV ONGC-2        | 16,815          | 26,467                 | 43,282           | 0.5%               |
| 11     | L&T-2               | 30,234          | 27,817                 | 58,051           | 0.8%               |
| 12     | Polysteel           | 1,80,359        | 27,185                 | 2,07,543         | 1.2%               |
| 13     | 11 kV Himgiri       | 64,024          | 36,420                 | 1,00,444         | 0.9%               |
| 14     | 11KV Trupti Casting | 33,813          | 37,012                 | 70,824           | 0.5%               |
| 15     | 11 kV Kalali        | 41,243          | 19,325                 | 60,568           | 0.3%               |
| 16     | 11 KV OM IGNOTS     | 38,922          | 20,974                 | 59,896           | 0.7%               |
| 17     | 11KV L&T            | 23,180          | 17,245                 | 40,425           | 0.5%               |

Table 38 - Technical loss calculation at 11 kV level for feeders on Group A - MGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name         | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|---------------------|------------------------------|-------------------------------|--------------------|
| 1      | Bharat Oman         | 63.1                         | 5,52,756                      | 2.8%               |
| 2      | 11 KV BODAL         | 75.7                         | 6,63,132                      | 2.4%               |
| 3      | Agrawal Mittal Exp  | 37.3                         | 3,26,748                      | 1.2%               |
| 4      | 11 KV ABS PLASTIC   | 12.3                         | 1,07,748                      | 0.6%               |
| 5      | Lupin               | 68.7                         | 6,01,812                      | 2.8%               |
| 6      | 11 kV Baroda Dairy  | 28.3                         | 2,47,908                      | 1.7%               |
| 7      | 11 KV ABS BAYER     | 42.3                         | 3,70,548                      | 2.2%               |
| 8      | 11 KV TS-2          | 3.3                          | 28,908                        | 0.4%               |
| 9      | 11 KV RR KABEL      | 33.2                         | 2,90,832                      | 1.8%               |
| 10     | 11 kV ONGC-2        | 6.5                          | 56,940                        | 0.7%               |
| 11     | L&T-2               | 9.5                          | 83,220                        | 1.2%               |
| 12     | Polysteel           | 27.9                         | 2,44,404                      | 1.4%               |
| 13     | 11 kV Himgiri       | 4.8                          | 42,048                        | 0.4%               |
| 14     | 11KV Trupti Casting | 8.4                          | 73,584                        | 0.5%               |
| 15     | 11 kV Kalali        | 7.7                          | 67,452                        | 0.3%               |
| 16     | 11 KV OM IGNOTS     | 5.1                          | 44,676                        | 0.5%               |
| 17     | 11KV L&T            | 6.8                          | 59,568                        | 0.7%               |

Table 39 - 11 kV loss results from ETAP software for feeders on Group A - MGCVL

### Comparison of ETAP loss with energy audit

Since MGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name        | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|--------------------|-----------------|---------------|-------------------------|-----------------------|
| 1      | Bharat Oman        | 2,570           | 0.03%         | 3,504                   | 0.04%                 |
| 2      | 11 KV BODAL        | 4,938           | 0.01%         | 11,388                  | 0.02%                 |
| 3      | Agrawal Mittal Exp | 1,558           | 0.02%         | 1,752                   | 0.01%                 |
| 4      | 11 KV ABS PLASTIC  | 496             | 0.01%         | 876                     | 0.02%                 |
| 5      | Lupin              | 3,129           | 0.01%         | 5,256                   | 0.02%                 |
| 6      | 11 kV Baroda Dairy | 936             | 0.01%         | 876                     | 0.01%                 |
| 7      | 11 KV ABS BAYER    | 2,114           | 0.01%         | 3,504                   | 0.01%                 |
| 8      | 11 KV TS-2         | 168             | 0.01%         | 1,752                   | 0.01%                 |
| 9      | 11 KV RR KABEL     | 2,125           | 0.00%         | 1,752                   | 0.01%                 |
| 10     | 11 kV ONGC-2       | 133             | 0.01%         | -                       | 0.01%                 |
| 11     | L&T-2              | 239             | 0.00%         | 876                     | 0.00%                 |
| 12     | Polysteel          | 1,425           | 0.00%         | 876                     | 0.01%                 |
| 13     | 11 kV Himgiri      | 506             | 0.00%         | 876                     | 0.01%                 |

| Sl No. | Feeder Name         | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|---------------------|-----------------|---------------|-------------------------|-----------------------|
| 14     | 11KV Trupti Casting | 348             | 0.00%         | 876                     | 0.00%                 |
| 15     | 11 kV Kalali        | 326             | 0.00%         | -                       | 0.00%                 |
| 16     | 11 KV OM IGNOTS     | 307             | 0.00%         | -                       | 0.00%                 |
| 17     | 11KV L&T            | 183             | 0.00%         | -                       | 0.01%                 |

Table 40 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below -

| Sl No. | Feeder Name         | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|---------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | Bharat Oman         | 2,570                 | 0.03%          | 3,504                   | 0.04%                      |
| 2      | 11 KV BODAL         | 4,938                 | 0.01%          | 11,388                  | 0.02%                      |
| 3      | Agrawal Mittal Exp  | 1,558                 | 0.02%          | 1,752                   | 0.01%                      |
| 4      | 11 KV ABS PLASTIC   | 496                   | 0.01%          | 876                     | 0.02%                      |
| 5      | Lupin               | 3,129                 | 0.01%          | 5,256                   | 0.02%                      |
| 6      | 11 kV Baroda Dairy  | 936                   | 0.01%          | 876                     | 0.01%                      |
| 7      | 11 KV ABS BAYER     | 2,114                 | 0.01%          | 3,504                   | 0.01%                      |
| 8      | 11 KV TS-2          | 168                   | 0.01%          | 1,752                   | 0.01%                      |
| 9      | 11 KV RR KABEL      | 2,125                 | 0.00%          | 1,752                   | 0.01%                      |
| 10     | 11 kV ONGC-2        | 133                   | 0.01%          | -                       | 0.01%                      |
| 11     | L&T-2               | 239                   | 0.00%          | 876                     | 0.00%                      |
| 12     | Polysteel           | 1,425                 | 0.00%          | 876                     | 0.01%                      |
| 13     | 11 kV Himgiri       | 506                   | 0.00%          | 876                     | 0.01%                      |
| 14     | 11KV Trupti Casting | 348                   | 0.00%          | 876                     | 0.00%                      |
| 15     | 11 kV Kalali        | 326                   | 0.00%          | -                       | 0.00%                      |
| 16     | 11 KV OM IGNOTS     | 307                   | 0.00%          | -                       | 0.00%                      |
| 17     | 11KV L&T            | 183                   | 0.00%          | -                       | 0.01%                      |

Table 41 - Loss calculation at 66 kV level for feeders on Group A - MGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name         | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|---------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | Bharat Oman         | 5,52,756                            | 3,504                   | 2.12                                | 0.12                    |
| 2      | 11 KV BODAL         | 6,63,132                            | 11,388                  | 2.12                                | 0.14                    |
| 3      | Agrawal Mittal Exp  | 3,26,748                            | 1,752                   | 2.12                                | 0.07                    |
| 4      | 11 KV ABS PLASTIC   | 1,07,748                            | 876                     | 2.12                                | 0.02                    |
| 5      | Lupin               | 6,01,812                            | 5,256                   | 2.12                                | 0.13                    |
| 6      | 11 kV Baroda Dairy  | 2,47,908                            | 876                     | 2.12                                | 0.05                    |
| 7      | 11 KV ABS BAYER     | 3,70,548                            | 3,504                   | 2.12                                | 0.08                    |
| 8      | 11 KV TS-2          | 28,908                              | 1,752                   | 2.12                                | 0.01                    |
| 9      | 11 KV RR KABEL      | 2,90,832                            | 1,752                   | 2.12                                | 0.06                    |
| 10     | 11 kV ONGC-2        | 56,940                              | -                       | 2.12                                | 0.01                    |
| 11     | L&T-2               | 83,220                              | 876                     | 2.12                                | 0.02                    |
| 12     | Polysteel           | 2,44,404                            | 876                     | 2.12                                | 0.05                    |
| 13     | 11 kV Himgiri       | 42,048                              | 876                     | 2.12                                | 0.01                    |
| 14     | 11KV Trupti Casting | 73,584                              | 876                     | 2.12                                | 0.02                    |
| 15     | 11 kV Kalali        | 67,452                              | -                       | 2.12                                | 0.01                    |
| 16     | 11 KV OM IGNOTS     | 44,676                              | -                       | 2.12                                | 0.01                    |
| 17     | 11KV L&T            | 59,568                              | -                       | 2.12                                | 0.01                    |

Table 42 - Annual saving due to conversion into 66 kV for feeders on Group A - MGCVL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name        | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|--------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | Bharat Oman        | 1,650                                | 1.03                                | 7.04                              | 8.07                                        |
| 2      | 11 KV BODAL        | 220                                  | 1.00                                | 10.77                             | 11.77                                       |
| 3      | Agrawal Mittal Exp | 1,320                                | 1.03                                | 2.36                              | 3.39                                        |
| 4      | 11 KV ABS PLASTIC  | 2,910                                | 1.06                                | 2.40                              | 3.45                                        |
| 5      | Lupin              | 220                                  | 1.00                                | 9.20                              | 10.21                                       |
| 6      | 11 kV Baroda Dairy | 5,530                                | 1.11                                | 4.38                              | 5.49                                        |
| 7      | 11 KV ABS BAYER    | 1,430                                | 1.03                                | 8.62                              | 9.64                                        |
| 8      | 11 KV TS-2         | 5,530                                | 1.11                                | 6.36                              | 7.47                                        |
| 9      | 11 KV RR KABEL     | 810                                  | 1.02                                | 8.43                              | 9.45                                        |
| 10     | 11 kV ONGC-2       | 5,530                                | 1.11                                | 4.75                              | 5.86                                        |

| Sl No. | Feeder Name         | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|---------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 11     | 11 kV L&T-2         | 810                                  | 1.02                                | 6.19                              | 7.20                                        |
| 12     | 11 kV Polysteel     | 1,320                                | 1.03                                | 6.78                              | 7.80                                        |
| 13     | 11 kV Himgiri       | 1,320                                | 1.03                                | 4.20                              | 5.23                                        |
| 14     | 11KV Trupti Casting | 2,150                                | 1.04                                | 2.57                              | 3.61                                        |
| 15     | 11 kV Kalali        | 220                                  | 1.00                                | 4.57                              | 5.57                                        |
| 16     | 11 KV OM IGNOTS     | 1,430                                | 1.03                                | 3.65                              | 4.68                                        |
| 17     | 11KV L&T            | 810                                  | 1.02                                | 6.04                              | 7.06                                        |

Table 43 - Conversion cost for supply at 66kV level for feeders on Group A - MGCVL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name              | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|--------------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kV Bharat Oman        | 8.07                                        | 0.12                    | 69                     |
| 2      | 11 KV BODAL              | 11.77                                       | 0.14                    | 85                     |
| 3      | 11 kV Agrawal Mittal Exp | 3.39                                        | 0.07                    | 49                     |
| 4      | 11 KV ABS PLASTIC        | 3.45                                        | 0.02                    | 152                    |
| 5      | 11 kV Lupin              | 10.21                                       | 0.13                    | 81                     |
| 6      | 11 kV Baroda Dairy       | 5.49                                        | 0.05                    | 105                    |
| 7      | 11 KV ABS BAYER          | 9.64                                        | 0.08                    | 124                    |
| 8      | 11 KV TS-2               | 7.47                                        | 0.01                    | 1,297                  |
| 9      | 11 KV RR KABEL           | 9.45                                        | 0.06                    | 154                    |
| 10     | 11 kV ONGC-2             | 5.86                                        | 0.01                    | 485                    |
| 11     | 11 kV L&T-2              | 7.20                                        | 0.02                    | 413                    |
| 12     | 11 kV Polysteel          | 7.80                                        | 0.05                    | 151                    |
| 13     | 11 kV Himgiri            | 5.23                                        | 0.01                    | 599                    |
| 14     | 11KV Trupti Casting      | 3.61                                        | 0.02                    | 234                    |
| 15     | 11 kV Kalali             | 5.57                                        | 0.01                    | 390                    |
| 16     | 11 KV OM IGNOTS          | 4.68                                        | 0.01                    | 494                    |
| 17     | 11KV L&T                 | 7.06                                        | 0.01                    | 559                    |

Table 44 - Payback period for conversion to 66 kV for feeders on Group A - MGCVL

# Analysis of 11 kV feeders on 100 mm<sup>2</sup> ACSR Dog & AAAC Dog conductors – Group B

## Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name       | Length (ckt km) | Consumer Name                    | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|-------------------|-----------------|----------------------------------|-----------------------|----------------------------|-------------|
| 1      | 11 kV Rishi       | 2.50            | Rishi FIBC                       | 2600                  | 1,82,15,490                | 86%         |
| 2      | P.B.M. HT EXP     | 0.51            | P.B.M. POLYTEX Ltd.              | 3400                  | 2,29,08,600                | 84%         |
| 3      | Jayshree          | 0.80            | M/S ADITYA BIRLA INSULATORS      | 3200                  | 2,02,74,818                | 79%         |
| 4      | Mayur             | 5.82            | M/S ASAHI SONGWON                | 4000                  | 3,11,44,858                | 77%         |
| 5      | 11 kv Amul        | 7.18            | M/S KAIRA DISTCO.OP MILK         | 2250                  | 1,80,69,580                | 73%         |
| 6      | 11 kv S.W.S.      | 10.48           | M/s Iscon Balaji Foods Pvt.Ltd   | 2000                  | 69,30,780                  | 62%         |
| 7      | ITI               | 22.80           | Asian Food Industries            | 2500                  | 1,52,31,639                | 56%         |
| 8      | 11 kv AMC (Raska) | 1.74            | THE ADD. CHIEF. ENG. (AMC) RASKA | 2700                  | 94,02,600                  | 44%         |
| 9      | Bharat Cable Exp  | 3.20            | M/S POLYCAB WIRES UNIT VI        | 4000                  | 1,36,55,220                | 42%         |
| 10     | 11 kV KEC         | 2.73            | KEC International                | 3500                  | 1,09,71,000                | 39%         |
| 11     | Guj. Propack      | 4.49            | M-S LOHANA STEELS PVT. LTD.      | 4000                  | 1,20,23,480                | 29%         |
| 12     | Parekh            | 6.77            | M/S.Appollo Dyechem Pvt.Ltd.,    | 2000                  | 94,09,260                  | 24%         |

Table 45 - Basic details of feeders in Group B – MGVL

## Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional I<sup>2</sup>R method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name | Load (Amps) | Loss Load Factor | Resistance of line (Ω) | Peak Power Loss (Watts) |
|--------|-------------|-------------|------------------|------------------------|-------------------------|
| 1      | 11 kV Rishi | 138         | 0.765            | 2.937                  | 55,934                  |

| Sl No. | Feeder Name       | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|-------------------|-------------|------------------|---------------------------------|-------------------------|
| 2      | P.B.M. HT EXP     | 169         | 0.740            | 0.605                           | 17,283                  |
| 3      | Jayshree          | 157         | 0.664            | 0.942                           | 23,213                  |
| 4      | Mayur             | 146         | 0.635            | 6.855                           | 1,46,118                |
| 5      | 11 kv Amul        | 77          | 0.572            | 8.517                           | 50,495                  |
| 6      | 11 kv S.W.S.      | 58          | 0.432            | 12.429                          | 41,810                  |
| 7      | ITI               | 72          | 0.363            | 26.840                          | 1,39,139                |
| 8      | 11 kv AMC (Raska) | 95          | 0.240            | 2.065                           | 18,632                  |
| 9      | Bharat Cable Exp  | 204         | 0.228            | 3.767                           | 1,56,769                |
| 10     | 11 kV KEC         | 121         | 0.201            | 3.214                           | 47,053                  |
| 11     | Guj. Propack      | 195         | 0.125            | 5.286                           | 2,00,986                |
| 12     | Parekh            | 60          | 0.092            | 7.964                           | 28,670                  |

Table 46 - Calculation of peak power losses at 11 kV for feeders in Group B – MGVCCL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name       | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-------------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11 kV Rishi       | 3,74,780        | 94,073                 | 4,68,853         | 2.6%               |
| 2      | P.B.M. HT EXP     | 1,12,066        | 1,19,052               | 2,31,118         | 1.0%               |
| 3      | Jayshree          | 1,34,960        | 1,00,464               | 2,35,424         | 1.2%               |
| 4      | Mayur             | 8,12,850        | 1,20,160               | 9,33,010         | 3.0%               |
| 5      | 11 kv Amul        | 2,53,160        | 60,914                 | 3,14,075         | 1.7%               |
| 6      | 11 kv S.W.S.      | 1,58,046        | 40,825                 | 1,98,871         | 2.9%               |
| 7      | ITI               | 4,42,300        | 42,914                 | 4,85,214         | 3.2%               |
| 8      | 11 kv AMC (Raska) | 39,250          | 30,713                 | 69,963           | 0.7%               |
| 9      | Bharat Cable Exp  | 3,13,514        | 43,197                 | 3,56,711         | 2.6%               |
| 10     | 11 kV KEC         | 82,854          | 33,281                 | 1,16,135         | 1.1%               |
| 11     | Guj. Propack      | 2,20,959        | 23,746                 | 2,44,705         | 2.0%               |
| 12     | Parekh            | 23,133          | 8,714                  | 31,847           | 0.3%               |

Table 47 - Technical loss calculation at 11 kV level for feeders in Group B – MGVCCL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name       | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|-------------------|------------------------------|-------------------------------|--------------------|
| 1      | 11 kV Rishi       | 60.7                         | 5,31,732                      | 2.9%               |
| 2      | P.B.M. HT EXP     | 26                           | 2,27,760                      | 1.0%               |
| 3      | Jayshree          | 26                           | 2,27,760                      | 1.1%               |
| 4      | Mayur             | 113.6                        | 9,95,136                      | 3.2%               |
| 5      | 11 kv Amul        | 39.2                         | 3,43,392                      | 1.9%               |
| 6      | 11 kv S.W.S.      | 22.4                         | 1,96,224                      | 2.8%               |
| 7      | ITI               | 54.2                         | 4,74,792                      | 3.1%               |
| 8      | 11 kv AMC (Raska) | 10.1                         | 88,476                        | 0.9%               |
| 9      | Bharat Cable Exp  | 44.7                         | 3,91,572                      | 2.9%               |
| 10     | 11 kV KEC         | 19.7                         | 1,72,572                      | 1.6%               |
| 11     | Guj. Propack      | 22.1                         | 1,93,596                      | 1.6%               |
| 12     | Parekh            | 5.3                          | 46,428                        | 0.5%               |

Table 48 - 11 kV loss results from ETAP software for feeders in Group B – MGVL

### Comparison of ETAP loss with energy audit

Since MGVL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name       | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|-------------------|-----------------|---------------|-------------------------|-----------------------|
| 1      | 11 kV Rishi       | 1,592           | 0.01%         | 1,752                   | 0.03%                 |
| 2      | P.B.M. HT EXP     | 472             | 0.15%         | 876                     | 0.18%                 |
| 3      | Jayshree          | 573             | 0.00%         | 876                     | 0.02%                 |
| 4      | Mayur*            | 22,579          | 0.00%         | 42,924                  | 0.00%                 |
| 5      | 11 kv Amul        | 1,067           | 0.02%         | 876                     | 0.02%                 |
| 6      | 11 kv S.W.S.      | 666             | 0.07%         | -                       | 0.05%                 |
| 7      | ITI               | 1,879           | 0.01%         | 876                     | 0.01%                 |
| 8      | 11 kv AMC (Raska) | 165             | 0.07%         | -                       | 0.05%                 |
| 9      | Bharat Cable Exp* | 8,709           | 0.00%         | 7,008                   | 0.00%                 |
| 10     | 11 kV KEC         | 352             | 0.00%         | 876                     | 0.00%                 |
| 11     | Guj. Propack*     | 6,138           | 0.00%         | 4,380                   | 0.01%                 |
| 12     | Parekh*           | 643             | 0.00%         | 876                     | 0.00%                 |

Table 49 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name       | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|-------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11 kV Rishi       | 1,592                 | 0.01%          | 1,752                   | 0.03%                      |
| 2      | P.B.M. HT EXP     | 472                   | 0.15%          | 876                     | 0.18%                      |
| 3      | Jayshree          | 573                   | 0.00%          | 876                     | 0.02%                      |
| 4      | Mayur*            | 22,579                | 0.00%          | 42,924                  | 0.00%                      |
| 5      | 11 kv Amul        | 1,067                 | 0.02%          | 876                     | 0.02%                      |
| 6      | 11 kv S.W.S.      | 666                   | 0.07%          | -                       | 0.05%                      |
| 7      | ITI               | 1,879                 | 0.01%          | 876                     | 0.01%                      |
| 8      | 11 kv AMC (Raska) | 165                   | 0.07%          | -                       | 0.05%                      |
| 9      | Bharat Cable Exp* | 8,709                 | 0.00%          | 7,008                   | 0.00%                      |
| 10     | 11 kV KEC         | 352                   | 0.00%          | 876                     | 0.00%                      |
| 11     | Guj. Propack*     | 6,138                 | 0.00%          | 4,380                   | 0.01%                      |
| 12     | Parekh*           | 643                   | 0.00%          | 876                     | 0.00%                      |

Table 50 - Loss calculation at 66 kV level for feeders in Group B – MGVL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name       | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|-------------------|-------------------------------------|-------------------------|--------------------------------|-------------------------|
| 1      | 11 kV Rishi       | 5,31,732                            | 1,752                   | 2.12                           | 0.11                    |
| 2      | P.B.M. HT EXP     | 2,27,760                            | 876                     | 2.12                           | 0.05                    |
| 3      | Jayshree          | 2,27,760                            | 876                     | 2.12                           | 0.05                    |
| 4      | Mayur*            | 9,95,136                            | 42,924                  | 2.12                           | 0.20                    |
| 5      | 11 kv Amul        | 3,43,392                            | 876                     | 2.12                           | 0.07                    |
| 6      | 11 kv S.W.S.      | 1,96,224                            | -                       | 2.12                           | 0.04                    |
| 7      | ITI               | 4,74,792                            | 876                     | 2.12                           | 0.10                    |
| 8      | 11 kv AMC (Raska) | 88,476                              | -                       | 2.12                           | 0.02                    |
| 9      | Bharat Cable Exp* | 3,91,572                            | 7,008                   | 2.12                           | 0.08                    |
| 10     | 11 kV KEC         | 1,72,572                            | 876                     | 2.12                           | 0.04                    |
| 11     | Guj. Propack*     | 1,93,596                            | 4,380                   | 2.12                           | 0.04                    |
| 12     | Parekh*           | 46,428                              | 876                     | 2.12                           | 0.01                    |

Table 51 - Annual saving due to conversion into 66 kV for feeders in Group B – MGVL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name       | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|-------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11 kV Rishi       | 220                                  | 1.00                                | 5.11                              | 6.12                                        |
| 2      | P.B.M. HT EXP     | 420                                  | 1.01                                | 1.46                              | 2.47                                        |
| 3      | Jayshree          | 1,320                                | 1.03                                | 1.99                              | 3.02                                        |
| 4      | Mayur*            | 220                                  | 1.00                                | 1.39                              | 2.40                                        |
| 5      | 11 kv Amul        | 420                                  | 1.01                                | 13.73                             | 14.74                                       |
| 6      | 11 kv S.W.S.      | 620                                  | 1.01                                | 19.79                             | 20.81                                       |
| 7      | ITI               | 1,650                                | 1.03                                | 42.47                             | 43.50                                       |
| 8      | 11 kv AMC (Raska) | 1,580                                | 1.03                                | 3.72                              | 4.75                                        |
| 9      | Bharat Cable Exp* | 1,320                                | 1.03                                | 1.00                              | 2.03                                        |
| 10     | 11 kV KEC         | 1,430                                | 1.03                                | 5.54                              | 6.57                                        |
| 11     | Guj. Propack*     | 810                                  | 1.02                                | 1.19                              | 2.21                                        |
| 12     | Parekh*           | 220                                  | 1.00                                | 1.53                              | 2.54                                        |

Table 52 - Conversion cost for supply at 66kV level for feeders in Group B – MGVCCL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name       | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|-------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kV Rishi       | 6.12                                        | 0.11                    | 54                     |
| 2      | P.B.M. HT EXP     | 2.47                                        | 0.05                    | 51                     |
| 3      | Jayshree          | 3.02                                        | 0.05                    | 63                     |
| 4      | Mayur*            | 2.40                                        | 0.20                    | 12                     |
| 5      | 11 kv Amul        | 14.74                                       | 0.07                    | 203                    |
| 6      | 11 kv S.W.S.      | 20.81                                       | 0.04                    | 500                    |
| 7      | ITI               | 43.50                                       | 0.10                    | 433                    |
| 8      | 11 kv AMC (Raska) | 4.75                                        | 0.02                    | 253                    |
| 9      | Bharat Cable Exp* | 2.03                                        | 0.08                    | 25                     |
| 10     | 11 kV KEC         | 6.57                                        | 0.04                    | 181                    |
| 11     | Guj. Propack*     | 2.21                                        | 0.04                    | 55                     |

| Sl No. | Feeder Name | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|-------------|---------------------------------------------|-------------------------|------------------------|
| 12     | Parekh*     | 2.54                                        | 0.01                    | 263                    |

Table 53 - Payback period for conversion to 66 kV for feeders in Group B – MGVCL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

## Analysis of 11 kV feeders on 55 mm<sup>2</sup> ACSR Rabbit & 55 mm<sup>2</sup> AAAC Rabbit conductors – Group C

### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name   | Length (ckt km) | Consumer Name                  | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|---------------|-----------------|--------------------------------|-----------------------|----------------------------|-------------|
| 1      | 11 kv GIDC    | 6.45            | H.M.INDUSTRIAL PVT.LTD.        | 2000                  | 89,48,429                  | 54%         |
| 2      | K.P.MILL      | 1.00            | M/S SETCO AUTOMOTIVE LTD.      | 2000                  | 77,90,520                  | 50%         |
| 3      | Torrent       | 1.32            | M/s Torrent Cable Ltd.         | 2500                  | 98,12,100                  | 49%         |
| 4      | 11 KV GMC     | 3.80            | GUJRAT METALCAST IND.          | 2000                  | 76,99,920                  | 48%         |
| 5      | GUJARAT CYCLE | 1.50            | M/S MUNJAL AUTO INDUSTRIES LTD | 2500                  | 91,47,240                  | 46%         |
| 6      | Windar        | 1.50            | M/S WINDAR RENEWABLE           | 2000                  | 6,04,220                   | 17%         |
| 7      | 11 KV INARCO  | 4.20            | HY-TUFF STEEL PVT.LTD.         | 2100                  | 1,11,29,539                | 15%         |

Table 54 - Basic details of feeders in Group C - MGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional I<sup>2</sup>R method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name | Load (Amps) | Loss Load Factor | Resistance of line (Ω) | Peak Power Loss (Watts) |
|--------|-------------|-------------|------------------|------------------------|-------------------------|
| 1      | 11 kv GIDC  | 50          | 0.341            | 13.994                 | 34,986                  |
| 2      | K.P.MILL    | 56          | 0.298            | 2.169                  | 6,802                   |

| Sl No. | Feeder Name   | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|---------------|-------------|------------------|---------------------------------|-------------------------|
| 3      | Torrent       | 116         | 0.295            | 2.863                           | 38,526                  |
| 4      | 11 KV GMC     | 89          | 0.278            | 8.242                           | 65,286                  |
| 5      | GUJARAT CYCLE | 54          | 0.265            | 3.254                           | 9,487                   |
| 6      | Windar        | 62          | 0.059            | 3.254                           | 12,506                  |
| 7      | 11 KV INARCO  | 136         | 0.049            | 9.779                           | 1,80,870                |

Table 55 - Calculation of peak power losses at 11 kV for feeders in Group C - MGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.x

| Sl No. | Feeder Name   | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|---------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11 kv GIDC    | 1,04,595        | 32,288                 | 1,36,882         | 1.5%               |
| 2      | K.P.MILL      | 17,741          | 28,168                 | 45,909           | 0.6%               |
| 3      | Torrent       | 99,468          | 34,855                 | 1,34,323         | 1.4%               |
| 4      | 11 KV GMC     | 1,58,955        | 26,295                 | 1,85,250         | 2.4%               |
| 5      | GUJARAT CYCLE | 21,994          | 31,297                 | 53,292           | 0.6%               |
| 6      | Windar        | 6,465           | 5,583                  | 12,048           | 2.0%               |
| 7      | 11 KV INARCO  | 78,107          | 4,897                  | 83,004           | 0.7%               |

Table 56 - Technical loss calculation at 11 kV level for feeders in Group C - MGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name   | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|---------------|------------------------------|-------------------------------|--------------------|
| 1      | 11 kv GIDC    | 18.7                         | 1,63,812                      | 1.8%               |
| 2      | K.P.MILL      | 7.5                          | 65,700                        | 0.8%               |
| 3      | Torrent       | 14.4                         | 1,26,144                      | 1.3%               |
| 4      | 11 KV GMC     | 24.4                         | 2,13,744                      | 2.8%               |
| 5      | GUJARAT CYCLE | 0.9                          | 7,884                         | 0.1%               |
| 6      | Windar        | 1.2                          | 10,512                        | 1.7%               |
| 7      | 11 KV INARCO  | 10.9                         | 95,484                        | 0.9%               |

Table 57 - 11 kV loss results from ETAP software for feeders in Group C - MGCVL

## Comparison of ETAP loss with energy audit

Since MGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name   | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|---------------|-----------------|---------------|-------------------------|-----------------------|
| 1      | 11 kv GIDC    | 241             | 0.01%         | -                       | 0.00%                 |
| 2      | K.P.MILL      | 41              | 0.00%         | -                       | 0.00%                 |
| 3      | Torrent       | 229             | 0.00%         | -                       | 0.00%                 |
| 4      | 11 KV GMC     | 366             | 0.00%         | 876                     | 0.01%                 |
| 5      | GUJARAT CYCLE | 51              | 0.00%         | -                       | 0.00%                 |
| 6      | Windar        | 15              | 0.00%         | -                       | 0.00%                 |
| 7      | 11 KV INARCO  | 168             | 0.00%         | -                       | 0.00%                 |

Table 58 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name   | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|---------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11 kv GIDC    | 241                   | 0.01%          | -                       | 0.00%                      |
| 2      | K.P.MILL      | 41                    | 0.00%          | -                       | 0.00%                      |
| 3      | Torrent       | 229                   | 0.00%          | -                       | 0.00%                      |
| 4      | 11 KV GMC     | 366                   | 0.00%          | 876                     | 0.01%                      |
| 5      | GUJARAT CYCLE | 51                    | 0.00%          | -                       | 0.00%                      |
| 6      | Windar        | 15                    | 0.00%          | -                       | 0.00%                      |
| 7      | 11 KV INARCO  | 168                   | 0.00%          | -                       | 0.00%                      |

Table 59 - Loss calculation at 66 kV level for feeders in Group C - MGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name   | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|---------------|-------------------------------------|-------------------------|--------------------------------|-------------------------|
| 1      | 11 kv GIDC    | 1,63,812                            | -                       | 2.12                           | 0.03                    |
| 2      | K.P.MILL      | 65,700                              | -                       | 2.12                           | 0.01                    |
| 3      | Torrent       | 1,26,144                            | -                       | 2.12                           | 0.03                    |
| 4      | 11 KV GMC     | 2,13,744                            | 876                     | 2.12                           | 0.05                    |
| 5      | GUJARAT CYCLE | 7,884                               | -                       | 2.12                           | 0.00                    |

| Sl No. | Feeder Name  | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|--------------|-------------------------------------|-------------------------|--------------------------------|-------------------------|
| 6      | Windar       | 10,512                              | -                       | 2.12                           | 0.00                    |
| 7      | 11 KV INARCO | 95,484                              | -                       | 2.12                           | 0.02                    |

Table 60 - Annual saving due to conversion into 66 kV for feeders in Group C - MGCVL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name   | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|---------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11 kv GIDC    | 420                                  | 1.01                                | 12.39                             | 13.40                                       |
| 2      | K.P.MILL      | 520                                  | 1.01                                | 2.36                              | 3.37                                        |
| 3      | Torrent       | 1,650                                | 1.03                                | 2.95                              | 3.98                                        |
| 4      | 11 KV GMC     | 5,530                                | 1.11                                | 7.51                              | 8.62                                        |
| 5      | GUJARAT CYCLE | 810                                  | 1.02                                | 3.28                              | 4.30                                        |
| 6      | Windar        | 1,320                                | 1.03                                | 3.28                              | 4.31                                        |
| 7      | 11 KV INARCO  | 5,530                                | 1.11                                | 8.25                              | 9.36                                        |

Table 61 - Conversion cost for supply at 66kV level for feeders in Group C - MGCVL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name   | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|---------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kv GIDC    | 13.40                                       | 0.03                    | 386                    |
| 2      | K.P.MILL      | 3.37                                        | 0.01                    | 242                    |
| 3      | Torrent       | 3.98                                        | 0.03                    | 149                    |
| 4      | 11 KV GMC     | 8.62                                        | 0.05                    | 191                    |
| 5      | GUJARAT CYCLE | 4.30                                        | 0.00                    | 2,570                  |
| 6      | Windar        | 4.31                                        | 0.00                    | 1,932                  |
| 7      | 11 KV INARCO  | 9.36                                        | 0.02                    | 462                    |

Table 62 - Payback period for conversion to 66 kV for feeders in Group C - MGCVL

## Analysis of 11 kV feeders on 70 mm<sup>2</sup> & 95 mm<sup>2</sup> AB Cables – Group D

### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name      | Length (ckt km) | Consumer Name     | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|------------------|-----------------|-------------------|-----------------------|----------------------------|-------------|
| 1      | 11 kV Raniya Ind | 2.79            | Shaily Plastics   | 2500                  | 2,25,34,407                | 94%         |
| 2      | Amber            | 5.55            | M/S.Amber Spintex | 2500                  | 1,82,80,500                | 89%         |
| 3      | 11 kV GE Plastic | 2.25            | Sabic Innovative  | 3500                  | 1,41,07,792                | 80%         |
| 4      | Ceramic          | 5.08            | WESTERN INDIA     | 2200                  | 78,57,960                  | 65%         |
| 5      | 11 KV HETTICH    | 5.00            | M/S HETTICH INDIA | 2100                  | 48,04,480                  | 58%         |

Table 63 - Basic details of feeders in Group D - MGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional I<sup>2</sup>R method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name      | Load (Amps) | Loss Load Factor | Resistance of line (Ω) | Peak Power Loss (Watts) |
|--------|------------------|-------------|------------------|------------------------|-------------------------|
| 1      | 11 kV Raniya Ind | 126         | 0.890            | 3.432                  | 54,482                  |
| 2      | Amber            | 103         | 0.809            | 9.441                  | 1,00,155                |
| 3      | 11 kV GE Plastic | 130         | 0.672            | 2.768                  | 46,771                  |
| 4      | Ceramic          | 67          | 0.468            | 6.248                  | 28,049                  |
| 5      | 11 KV HETTICH    | 57          | 0.385            | 6.150                  | 19,981                  |

Table 64 - Calculation of peak power losses at 11 kV for feeders in Group D - MGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name      | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|------------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11 kV Raniya Ind | 4,24,627        | 1,05,218               | 5,29,845         | 2.4%               |
| 2      | Amber            | 7,09,519        | 95,637                 | 8,05,156         | 4.4%               |
| 3      | 11 kV GE Plastic | 2,75,326        | 1,11,259               | 3,86,585         | 2.7%               |

| Sl No. | Feeder Name   | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|---------------|-----------------|------------------------|------------------|--------------------|
| 4      | Ceramic       | 1,14,992        | 48,704                 | 1,63,696         | 2.1%               |
| 5      | 11 KV HETTICH | 67,410          | 38,257                 | 1,05,667         | 2.2%               |

Table 65 - Technical loss calculation at 11 kV level for feeders in Group D - MGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name      | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|------------------|------------------------------|-------------------------------|--------------------|
| 1      | 11 kV Raniya Ind | 61.9                         | 5,42,244                      | 2.4%               |
| 2      | Amber            | 92.5                         | 8,10,300                      | 4.4%               |
| 3      | 11 kV GE Plastic | 43.9                         | 3,84,564                      | 2.7%               |
| 4      | Ceramic          | 20.8                         | 1,82,208                      | 2.3%               |
| 5      | 11 KV HETTICH    | 13.8                         | 1,20,888                      | 2.5%               |

Table 66 - 11 kV loss results from ETAP software for feeders in Group D - MGCVL

### Comparison of ETAP loss with energy audit

Since MGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name      | ETAP Loss (kWh) | ETAP Loss (%) | Energy audit loss (kWh) | Energy audit loss (%) |
|--------|------------------|-----------------|---------------|-------------------------|-----------------------|
| 1      | 11 kV Raniya Ind | 5,42,244        | 2.4%          | 4,81,143                | 2.1%                  |
| 2      | Amber            | 8,10,300        | 4.4%          | 7,74,780                | 4.2%                  |
| 3      | 11 kV GE Plastic | 3,84,564        | 2.7%          | 4,03,098                | 2.9%                  |
| 4      | Ceramic          | 1,82,208        | 2.3%          | -29,940                 | -0.4%                 |
| 5      | 11 KV HETTICH    | 1,20,888        | 2.5%          | 1,34,620                | 2.8%                  |

Table 67 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name      | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11 kV Raniya Ind | 1,726                 | 0.02%          | 2,628                   | 0.03%                      |
| 2      | Amber            | 2,086                 | 0.01%          | 4,380                   | 0.01%                      |

| Sl No. | Feeder Name      | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|------------------|-----------------------|----------------|-------------------------|----------------------------|
| 3      | 11 kV GE Plastic | 1,119                 | 0.01%          | 876                     | 0.01%                      |
| 4      | Ceramic          | 467                   | 0.00%          | 876                     | 0.01%                      |
| 5      | 11 KV HETTICH    | 274                   | 0.00%          | -                       | 0.00%                      |

Table 68 - Loss calculation at 66 kV level for feeders in Group D - MGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name      | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | 11 kV Raniya Ind | 5,42,244                            | 2,628                   | 2.12                                | 0.11                    |
| 2      | Amber            | 8,10,300                            | 4,380                   | 2.12                                | 0.17                    |
| 3      | 11 kV GE Plastic | 3,84,564                            | 876                     | 2.12                                | 0.08                    |
| 4      | Ceramic          | 1,82,208                            | 876                     | 2.12                                | 0.04                    |
| 5      | 11 KV HETTICH    | 1,20,888                            | -                       | 2.12                                | 0.03                    |

Table 69 - Annual saving due to conversion into 66 kV for feeders in Group D - MGCVL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name      | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11 kV Raniya Ind | 1,430                                | 1.03                                | 5.65                              | 6.68                                        |
| 2      | Amber            | 220                                  | 1.00                                | 10.73                             | 11.74                                       |
| 3      | 11 kV GE Plastic | 1,050                                | 1.02                                | 4.66                              | 5.68                                        |
| 4      | Ceramic          | 220                                  | 1.00                                | 9.87                              | 10.87                                       |
| 5      | 11 KV HETTICH    | 1,750                                | 1.03                                | 9.72                              | 10.75                                       |

Table 70 - Conversion cost for supply at 66kV level for feeders in Group D - MGCVL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name      | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kV Raniya Ind | 6.68                                        | 0.11                    | 58                     |
| 2      | Amber            | 11.74                                       | 0.17                    | 69                     |
| 3      | 11 kV GE Plastic | 5.68                                        | 0.08                    | 70                     |
| 4      | Ceramic          | 10.87                                       | 0.04                    | 283                    |
| 5      | 11 KV HETTICH    | 10.75                                       | 0.03                    | 420                    |

Table 71 - Payback period for conversion to 66 kV for feeders in Group D - MGCVL

## CHAPTER: 6 ANALYSIS OF SAMPLE FEEDERS - PGVCL

Details of sample feeders chosen for PGVCL area are as follows –

| Group        | Configuration                                                       | Feeder type | Numbers   |
|--------------|---------------------------------------------------------------------|-------------|-----------|
| Group A      | 11 kV feeders on overhead AAAC Dog conductor (100 mm <sup>2</sup> ) | Express     | 33        |
| Group B      | 11 kV feeders on OH AAAC Rabbit conductor (55 mm <sup>2</sup> )     | Express     | 17        |
| <b>Total</b> |                                                                     |             | <b>50</b> |

Table 72 - Classification of sample feeders - PGVCL

Each of these feeder types are analysed in separate groups in subsequent sections of this chapter.

### Analysis of 11 kV feeders on 100 mm<sup>2</sup> AAAC Dog Conductor – Group A

#### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name      | Length (ckt km) | Consumer Name     | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|------------------|-----------------|-------------------|-----------------------|----------------------------|-------------|
| 1      | 11 kV Aajveto    | 2.60            | Laffans Granito   | 2500                  | 2,43,67,400                | 95%         |
| 2      | JETPAR JGY       | 4.65            | M/S BLUEZONE      | 2750                  | 2,18,24,720                | 93%         |
| 3      | ITALUS IND.      | 3.30            | M/S ITALUS        | 2600                  | 1,88,67,040                | 93%         |
| 4      | 11 kV Lakme      | 2.70            | Lakme Vitified    | 2500                  | 3,27,33,200                | 90%         |
| 5      | 11 kV Milano     | 2.50            | Milano Papers     | 3200                  | 1,45,62,900                | 87%         |
| 6      | 11 kV Aditya     | 2.28            | Aditya Ultra      | 2500                  | 1,48,91,200                | 86%         |
| 7      | 11 kV Falcon     | 2.80            | Falcon Yarns      | 3500                  | 2,51,77,280                | 85%         |
| 8      | AJANTA           | 5.47            | M/s AJANTA LLP    | 2800                  | 1,54,23,500                | 81%         |
| 9      | 11 kV Shakti Ind | 2.43            | Metropole Tiles   | 2500                  | 1,54,52,370                | 77%         |
| 10     | 11 kV Narmada    | 2.10            | SM, GWIL          | 3000                  | 1,45,46,220                | 76%         |
| 11     | 11KV KT MILL EXP | 8.90            | Bharat Industries | 2900                  | 1,01,81,860                | 75%         |
| 12     | ARIHANT FEEDER   | 3.50            | NEW VARDHMAN      | 4000                  | 2,01,81,500                | 72%         |
| 13     | 11 kV Varmora    | 2.20            | Shunshine Tiles   | 4000                  | 2,82,65,820                | 68%         |

| Sl No. | Feeder Name          | Length (ckt km) | Consumer Name      | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|----------------------|-----------------|--------------------|-----------------------|----------------------------|-------------|
| 14     | 11 kV Lemorex        | 2.30            | Lemorex Granito    | 2700                  | 1,40,27,200                | 65%         |
| 15     | EURO                 | 3.45            | M/S TAURUS TILES   | 2500                  | 51,98,641                  | 63%         |
| 16     | 11 kV Vishnu         | 2.30            | Lorenzo Vittrified | 3000                  | 1,65,79,800                | 62%         |
| 17     | MADHAV METCAST       | 4.96            | MADHAV METCAST     | 3800                  | 90,88,313                  | 62%         |
| 18     | 11 kV Clan           | 2.37            | Clan Vittrified    | 3300                  | 1,56,43,980                | 61%         |
| 19     | STEFINA              | 4.25            | STEFINA VITRIFIED  | 2500                  | 2,28,09,900                | 59%         |
| 20     | STEFINA              | 4.05            | CREVITA GRANITO    | 2500                  | 2,28,09,900                | 58%         |
| 21     | EMBOZA               | 3.94            | EMBOZA GRANITO     | 3200                  | 1,57,79,460                | 58%         |
| 22     | ARMANO               | 3.58            | ARMANO VITRIFIED   | 2800                  | 1,97,08,000                | 57%         |
| 23     | COLOR                | 3.83            | COLOR GRANITO      | 2500                  | 1,02,55,732                | 56%         |
| 24     | ASTRON EXPRESS       | 4.40            | ASTRON PAPER       | 2900                  | 1,27,32,280                | 55%         |
| 25     | LIVA IND.            | 3.35            | M/S NOKEN LTD.     | 3000                  | 1,76,75,470                | 49%         |
| 26     | SANSKAR              | 3.53            | M/S. SANSKAR       | 2700                  | 1,10,66,720                | 44%         |
| 27     | ELECTROMELT          | 6.20            | M/S. SHRI ELECTRO  | 4000                  | 1,32,67,151                | 38%         |
| 28     | 11 kV Vallabh Ispat  | 2.87            | Vallabh Ispat      | 4000                  | 1,06,07,200                | 33%         |
| 29     | SARDAR               | 5.20            | Capital Steel Ind  | 2800                  | 1,09,17,284                | 33%         |
| 30     | 11 kV Krishna Ispat  | 2.90            | Krishna Ispat      | 3000                  | 1,13,97,581                | 30%         |
| 31     | 11 kV Vallabh Alloys | 2.60            | Vallabh Alloys     | 4000                  | 12,80,191                  | 28%         |
| 32     | 11 kV KAG            | 2.71            | KAG Granino        | 2750                  | 61,27,200                  | 24%         |
| 33     | 11 kV Admin          | 2.42            | Admin Vittrified   | 2500                  | 35,41,193                  | 10%         |

Table 73 - Basic details of feeders in Group A - PGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional  $I^2R$  method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name   | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|---------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | 11 kV Aajveto | 218         | 0.912            | 3.085                           | 1,46,607                |

| Sl No. | Feeder Name          | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|----------------------|-------------|------------------|---------------------------------|-------------------------|
| 2      | JETPAR JGY           | 135         | 0.878            | 5.517                           | 1,00,551                |
| 3      | ITALUS IND.          | 140         | 0.878            | 3.915                           | 76,743                  |
| 4      | 11 kV Lakme          | 219         | 0.828            | 3.204                           | 1,53,645                |
| 5      | 11 kV Milano         | 130         | 0.780            | 2.966                           | 50,130                  |
| 6      | 11 kV Aditya         | 187         | 0.764            | 2.705                           | 94,599                  |
| 7      | 11 kV Falcon         | 172         | 0.751            | 3.322                           | 98,284                  |
| 8      | AJANTA               | 108         | 0.687            | 6.490                           | 75,701                  |
| 9      | 11 kV Shakti Ind     | 146         | 0.633            | 2.883                           | 61,458                  |
| 10     | 11 kV Narmada        | 174         | 0.614            | 2.492                           | 75,437                  |
| 11     | 11KV KT MILL EXP     | 106         | 0.600            | 10.556                          | 1,18,610                |
| 12     | ARIHANT FEEDER       | 136         | 0.559            | 4.153                           | 76,809                  |
| 13     | 11 kV Varmora        | 244         | 0.504            | 2.610                           | 1,55,407                |
| 14     | 11 kV Lemorex        | 83          | 0.473            | 2.729                           | 18,800                  |
| 15     | EURO                 | 67          | 0.446            | 4.093                           | 18,375                  |
| 16     | 11 kV Vishnu         | 157         | 0.432            | 2.729                           | 67,266                  |
| 17     | MADHAV METCAST       | 111         | 0.432            | 5.879                           | 72,436                  |
| 18     | 11 kV Clan           | 95          | 0.419            | 2.812                           | 25,378                  |
| 19     | STEFINA              | 71          | 0.402            | 5.043                           | 25,420                  |
| 20     | STEFINA              | 68          | 0.385            | 4.805                           | 22,220                  |
| 21     | EMBOZA               | 176         | 0.382            | 4.675                           | 1,44,807                |
| 22     | ARMANO               | 186         | 0.378            | 4.248                           | 1,46,952                |
| 23     | COLOR                | 64          | 0.367            | 4.544                           | 18,613                  |
| 24     | ASTRON EXPRESS       | 96          | 0.351            | 5.221                           | 48,113                  |
| 25     | LIVA IND.            | 138         | 0.291            | 3.975                           | 75,696                  |
| 26     | SANSKAR              | 122         | 0.241            | 4.188                           | 62,339                  |
| 27     | ELECTROMELT          | 165         | 0.193            | 7.356                           | 2,00,275                |
| 28     | 11 kV Vallabh Ispat  | 151         | 0.153            | 3.405                           | 77,643                  |
| 29     | SARDAR               | 113         | 0.153            | 6.170                           | 78,782                  |
| 30     | 11 kV Krishna Ispat  | 132         | 0.130            | 3.441                           | 59,953                  |
| 31     | 11 kV Vallabh Alloys | 52          | 0.119            | 3.085                           | 8,342                   |
| 32     | 11 kV KAG            | 83          | 0.093            | 3.215                           | 22,151                  |
| 33     | 11 kV Admin          | 16          | 0.027            | 2.871                           | 735                     |

Table 74 - Calculation of peak power losses at 11 kV for feeders in Group A - PGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name          | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|----------------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11 kV Aajveto        | 11,71,259       | 1,07,853               | 12,79,112        | 5.2%               |
| 2      | JETPAR JGY           | 7,73,299        | 1,14,205               | 8,87,504         | 4.1%               |
| 3      | ITALUS IND.          | 5,90,197        | 1,07,976               | 6,98,172         | 3.7%               |
| 4      | 11 kV Lakme          | 11,14,434       | 97,919                 | 12,12,353        | 3.7%               |
| 5      | 11 kV Milano         | 3,42,315        | 1,17,998               | 4,60,313         | 3.2%               |
| 6      | 11 kV Aditya         | 6,32,851        | 90,313                 | 7,23,164         | 4.9%               |
| 7      | 11 kV Falcon         | 6,46,197        | 1,24,264               | 7,70,460         | 3.1%               |
| 8      | AJANTA               | 4,55,499        | 90,978                 | 5,46,477         | 3.5%               |
| 9      | 11 kV Shakti Ind     | 3,40,534        | 74,802                 | 4,15,337         | 2.7%               |
| 10     | 11 kV Narmada        | 4,05,890        | 87,164                 | 4,93,055         | 3.4%               |
| 11     | 11KV KT MILL EXP     | 6,23,417        | 82,309                 | 7,05,726         | 6.9%               |
| 12     | ARIHANT FEEDER       | 3,75,934        | 1,05,719               | 4,81,653         | 2.4%               |
| 13     | 11 kV Varmora        | 6,86,112        | 95,363                 | 7,81,475         | 2.8%               |
| 14     | 11 kV Lemorex        | 77,955          | 60,457                 | 1,38,412         | 1.0%               |
| 15     | EURO                 | 71,866          | 52,798                 | 1,24,664         | 2.4%               |
| 16     | 11 kV Vishnu         | 2,54,531        | 61,300                 | 3,15,830         | 1.9%               |
| 17     | MADHAV METCAST       | 2,73,818        | 77,568                 | 3,51,386         | 3.9%               |
| 18     | 11 kV Clan           | 93,086          | 65,363                 | 1,58,449         | 1.0%               |
| 19     | STEFINA              | 89,495          | 47,529                 | 1,37,023         | 0.6%               |
| 20     | STEFINA              | 74,867          | 45,487                 | 1,20,354         | 0.5%               |
| 21     | EMBOZA               | 4,84,144        | 57,773                 | 5,41,917         | 3.4%               |
| 22     | ARMANO               | 4,86,304        | 50,036                 | 5,36,341         | 2.7%               |
| 23     | COLOR                | 59,804          | 43,375                 | 1,03,179         | 1.0%               |
| 24     | ASTRON EXPRESS       | 1,47,960        | 48,159                 | 1,96,119         | 1.5%               |
| 25     | LIVA IND.            | 1,92,788        | 41,259                 | 2,34,047         | 1.3%               |
| 26     | SANSKAR              | 1,31,703        | 30,803                 | 1,62,505         | 1.5%               |
| 27     | ELECTROMELT          | 3,38,303        | 36,487                 | 3,74,790         | 2.8%               |
| 28     | 11 kV Vallabh Ispat  | 1,04,055        | 28,948                 | 1,33,003         | 1.3%               |
| 29     | SARDAR               | 1,05,344        | 20,218                 | 1,25,562         | 1.2%               |
| 30     | 11 kV Krishna Ispat  | 68,294          | 18,454                 | 86,748           | 0.8%               |
| 31     | 11 kV Vallabh Alloys | 8,675           | 22,464                 | 31,139           | 2.4%               |
| 32     | 11 kV KAG            | 18,005          | 12,070                 | 30,075           | 0.5%               |

| Sl No. | Feeder Name | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-------------|-----------------|------------------------|------------------|--------------------|
| 33     | 11 kV Admin | 177             | 3,249                  | 3,425            | 0.1%               |

Table 75 - Technical loss calculation at 11 kV level for feeders in Group A - PGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name          | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|----------------------|------------------------------|-------------------------------|--------------------|
| 1      | 11 kV Aajveto        | 159.1                        | 13,93,716                     | 5.7%               |
| 2      | JETPAR JGY           | 104.9                        | 9,18,924                      | 4.2%               |
| 3      | ITALUS IND.          | 93.3                         | 8,17,308                      | 4.3%               |
| 4      | 11 kV Lakme          | 149.8                        | 13,12,248                     | 4.0%               |
| 5      | 11 kV Milano         | 52.3                         | 4,58,148                      | 3.1%               |
| 6      | 11 kV Aditya         | 87.4                         | 7,65,624                      | 5.1%               |
| 7      | 11 kV Falcon         | 103.9                        | 9,10,164                      | 3.6%               |
| 8      | AJANTA               | 65.4                         | 5,72,904                      | 3.7%               |
| 9      | 11 kV Shakti Ind     | 48.7                         | 4,26,612                      | 2.8%               |
| 10     | 11 kV Narmada        | 63                           | 5,51,880                      | 3.8%               |
| 11     | 11KV KT MILL EXP     | 81.4                         | 7,13,064                      | 7.0%               |
| 12     | ARIHANT FEEDER       | 58.8                         | 5,15,088                      | 2.6%               |
| 13     | 11 kV Varmora        | 110.2                        | 9,65,352                      | 3.4%               |
| 14     | 11 kV Lemorex        | 13.4                         | 1,17,384                      | 0.8%               |
| 15     | EURO                 | 13.4                         | 1,17,384                      | 2.3%               |
| 16     | 11 kV Vishnu         | 43.4                         | 3,80,184                      | 2.3%               |
| 17     | MADHAV METCAST       | 43.9                         | 3,84,564                      | 4.2%               |
| 18     | 11 kV Clan           | 17.8                         | 1,55,928                      | 1.0%               |
| 19     | STEFINA              | 18                           | 1,57,680                      | 0.7%               |
| 20     | STEFINA              | 17                           | 1,48,920                      | 0.7%               |
| 21     | EMBOZA               | 69                           | 6,04,440                      | 3.8%               |
| 22     | ARMANO               | 56.1                         | 4,91,436                      | 2.5%               |
| 23     | COLOR                | 17.7                         | 1,55,052                      | 1.5%               |
| 24     | ASTRON EXPRESS       | 21.1                         | 1,84,836                      | 1.5%               |
| 25     | LIVA IND.            | 14.1                         | 1,23,516                      | 0.7%               |
| 26     | SANSKAR              | 20.7                         | 1,81,332                      | 1.6%               |
| 27     | ELECTROMELT          | 46.2                         | 4,04,712                      | 3.1%               |
| 28     | 11 kV Vallabh Ispat  | 23.8                         | 2,08,488                      | 2.0%               |
| 29     | SARDAR               | 15.2                         | 1,33,152                      | 1.2%               |
| 30     | 11 kV Krishna Ispat  | 7.7                          | 67,452                        | 0.6%               |
| 31     | 11 kV Vallabh Alloys | 3.4                          | 29,784                        | 2.3%               |
| 32     | 11 kV KAG            | 3.9                          | 34,164                        | 0.6%               |
| 33     | 11 kV Admin          | 0.5                          | 4,380                         | 0.1%               |

Table 76 - 11 kV loss results from ETAP software for feeders in Group A – PGCVL

### Comparison of ETAP loss with energy audit

Since PGCVL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name         | ETAP Loss (kWh) | ETAP Loss (%) | EA loss (kWh) | EA Loss (%) |
|--------|---------------------|-----------------|---------------|---------------|-------------|
| 1      | 11 kV Aajveto       | 13,93,716       | 5.7%          | 14,72,178     | 6.0%        |
| 2      | JETPAR JGY*         | 9,18,924        | 4.2%          | 15,92,082     | 7.3%        |
| 3      | ITALUS IND.*        | 8,17,308        | 4.3%          | 8,55,968      | 4.5%        |
| 4      | 11 kV Lakme         | 13,12,248       | 4.0%          | 13,70,447     | 4.2%        |
| 5      | 11 kV Milano        | 4,58,148        | 3.1%          | 1,51,942      | 1.0%        |
| 6      | 11 kV Aditya        | 7,65,624        | 5.1%          | 7,77,055      | 5.2%        |
| 7      | 11 kV Falcon*       | 9,10,164        | 3.6%          | 10,65,624     | 4.2%        |
| 8      | AJANTA              | 5,72,904        | 3.7%          | 5,75,472      | 3.7%        |
| 9      | 11 kV Shakti Ind    | 4,26,612        | 2.8%          | 2,17,900      | 1.4%        |
| 10     | 11 kV Narmada       | 5,51,880        | 3.8%          | 2,48,722      | 1.7%        |
| 11     | 11KV KT MILL EXP    | 7,13,064        | 7.0%          | 7,27,218      | 7.1%        |
| 12     | ARIHANT FEEDER      | 5,15,088        | 2.6%          | 4,97,990      | 2.5%        |
| 13     | 11 kV Varmora       | 9,65,352        | 3.4%          | 4,37,405      | 1.5%        |
| 14     | 11 kV Lemorex       | 1,17,384        | 0.8%          | 76,691        | 0.5%        |
| 15     | EURO                | 1,17,384        | 2.3%          | 89,272        | 1.7%        |
| 16     | 11 kV Vishnu        | 3,80,184        | 2.3%          | 4,34,279      | 2.6%        |
| 17     | MADHAV METCAST      | 3,84,564        | 4.2%          | 4,00,113      | 4.4%        |
| 18     | 11 kV Clan          | 1,55,928        | 1.0%          | -3,05,303     | -2.0%       |
| 19     | STEFINA             | 1,57,680        | 0.7%          | -3,35,409     | -1.5%       |
| 20     | STEFINA             | 1,48,920        | 0.7%          | -3,35,409     | -1.5%       |
| 21     | EMBOZA              | 6,04,440        | 3.8%          | 5,30,878      | 3.4%        |
| 22     | ARMANO*             | 4,91,436        | 2.5%          | 1,63,276      | 0.8%        |
| 23     | COLOR*              | 1,55,052        | 1.5%          | 1,10,908      | 1.1%        |
| 24     | ASTRON EXPRESS      | 1,84,836        | 1.5%          | 1,77,280      | 1.4%        |
| 25     | LIVA IND.           | 1,23,516        | 0.7%          | 40,705        | 0.2%        |
| 26     | SANSKAR             | 1,81,332        | 1.6%          | 11,67,027     | 10.5%       |
| 27     | ELECTROMELT         | 4,04,712        | 3.1%          | 4,48,019      | 3.4%        |
| 28     | 11 kV Vallabh Ispat | 2,08,488        | 2.0%          | 2,06,050      | 1.9%        |
| 29     | SARDAR              | 1,33,152        | 1.2%          | 1,92,499      | 1.8%        |

| Sl No. | Feeder Name          | ETAP Loss (kWh) | ETAP Loss (%) | EA loss (kWh) | EA Loss (%) |
|--------|----------------------|-----------------|---------------|---------------|-------------|
| 30     | 11 kV Krishna Ispat  | 67,452          | 0.6%          | 1,30,405      | 1.1%        |
| 31     | 11 kV Vallabh Alloys | 29,784          | 2.3%          | 27,766        | 2.2%        |
| 32     | 11 kV KAG            | 34,164          | 0.6%          | 9,64,395      | 15.7%       |
| 33     | 11 kV Admin          | 4,380           | 0.1%          | 8,14,591      | 23.0%       |

Table 77 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below -

| Sl No. | Feeder Name      | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11 kV Aajveto    | 4,936                 | 0.03%          | 876                     | 0.01%                      |
| 2      | JETPAR JGY*      | 21,312                | 0.02%          | 6,132                   | 0.02%                      |
| 3      | ITALUS IND.*     | 16,266                | 0.01%          | 7,008                   | 0.02%                      |
| 4      | 11 kV Lakme      | 4,696                 | 0.03%          | 1,752                   | 0.00%                      |
| 5      | 11 kV Milano     | 1,443                 | 0.01%          | 1,752                   | 0.01%                      |
| 6      | 11 kV Aditya     | 2,667                 | 0.10%          | -                       | 0.06%                      |
| 7      | 11 kV Falcon*    | 17,809                | 0.21%          | 19,272                  | 0.06%                      |
| 8      | AJANTA           | 1,920                 | 0.08%          | 1,752                   | 0.08%                      |
| 9      | 11 kV Shakti Ind | 1,435                 | 0.11%          | 1,752                   | 0.06%                      |
| 10     | 11 kV Narmada    | 1,710                 | 0.09%          | 1,752                   | 0.05%                      |
| 11     | 11KV KT MILL EXP | 2,627                 | 0.03%          | 876                     | 0.01%                      |
| 12     | ARIHANT FEEDER   | 1,584                 | 0.02%          | 3,504                   | 0.02%                      |
| 13     | 11 kV Varmora    | 2,891                 | 0.01%          | 2,628                   | 0.01%                      |
| 14     | 11 kV Lemorex    | 329                   | 0.01%          | 876                     | 0.02%                      |
| 15     | EURO             | 303                   | 0.01%          | 1,752                   | 0.01%                      |
| 16     | 11 kV Vishnu     | 1,073                 | 0.01%          | 876                     | 0.01%                      |
| 17     | MADHAV METCAST   | 1,154                 | 0.01%          | 876                     | 0.01%                      |
| 18     | 11 kV Clan       | 392                   | 0.00%          | 1,752                   | 0.00%                      |
| 19     | STEFINA          | 377                   | 0.00%          | 1,752                   | 0.00%                      |
| 20     | STEFINA          | 315                   | 0.01%          | 1,752                   | 0.01%                      |
| 21     | EMBOZA           | 2,040                 | 0.01%          | 2,628                   | 0.01%                      |
| 22     | ARMANO*          | 13,403                | 0.01%          | 7,008                   | 0.01%                      |
| 23     | COLOR*           | 1,648                 | 0.01%          | 6,132                   | 0.01%                      |

| Sl No. | Feeder Name          | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|----------------------|-----------------------|----------------|-------------------------|----------------------------|
| 24     | ASTRON EXPRESS       | 624                   | 0.01%          | 1,752                   | 0.01%                      |
| 25     | LIVA IND.            | 812                   | 0.01%          | 876                     | 0.01%                      |
| 26     | SANSKAR              | 555                   | 0.01%          | 876                     | 0.01%                      |
| 27     | ELECTROMELT          | 1,426                 | 0.01%          | -                       | 0.01%                      |
| 28     | 11 kV Vallabh Ispat  | 438                   | 0.01%          | 876                     | 0.01%                      |
| 29     | SARDAR               | 444                   | 0.01%          | 876                     | 0.05%                      |
| 30     | 11 kV Krishna Ispat  | 288                   | 0.00%          | -                       | 0.01%                      |
| 31     | 11 kV Vallabh Alloys | 37                    | 0.00%          | -                       | 0.01%                      |
| 32     | 11 kV KAG            | 76                    | 0.00%          | -                       | 0.00%                      |
| 33     | 11 kV Admin          | 1                     | 0.00%          | 876                     | 0.00%                      |

Table 78 - Loss calculation at 66 kV level for feeders in Group A – PGCVL

\*ASCR Dog conductor at 66 kV

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name      | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | 11 kV Aajveto    | 13,93,716                           | 876                     | 2.12                                | 0.30                    |
| 2      | JETPAR JGY*      | 9,18,924                            | 6,132                   | 2.12                                | 0.19                    |
| 3      | ITALUS IND.*     | 8,17,308                            | 7,008                   | 2.12                                | 0.17                    |
| 4      | 11 kV Lakme      | 13,12,248                           | 1,752                   | 2.12                                | 0.28                    |
| 5      | 11 kV Milano     | 4,58,148                            | 1,752                   | 2.12                                | 0.10                    |
| 6      | 11 kV Aditya     | 7,65,624                            | -                       | 2.12                                | 0.16                    |
| 7      | 11 kV Falcon*    | 9,10,164                            | 19,272                  | 2.12                                | 0.19                    |
| 8      | AJANTA           | 5,72,904                            | 1,752                   | 2.12                                | 0.12                    |
| 9      | 11 kV Shakti Ind | 4,26,612                            | 1,752                   | 2.12                                | 0.09                    |
| 10     | 11 kV Narmada    | 5,51,880                            | 1,752                   | 2.12                                | 0.12                    |
| 11     | 11KV KT MILL EXP | 7,13,064                            | 876                     | 2.12                                | 0.15                    |
| 12     | ARIHANT FEEDER   | 5,15,088                            | 3,504                   | 2.12                                | 0.11                    |
| 13     | 11 kV Varmora    | 9,65,352                            | 2,628                   | 2.12                                | 0.20                    |
| 14     | 11 kV Lemorex    | 1,17,384                            | 876                     | 2.12                                | 0.02                    |

| Sl No. | Feeder Name          | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|----------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 15     | EURO                 | 1,17,384                            | 1,752                   | 2.12                                | 0.02                    |
| 16     | 11 kV Vishnu         | 3,80,184                            | 876                     | 2.12                                | 0.08                    |
| 17     | MADHAV METCAST       | 3,84,564                            | 876                     | 2.12                                | 0.08                    |
| 18     | 11 kV Clan           | 1,55,928                            | 1,752                   | 2.12                                | 0.03                    |
| 19     | STEFINA              | 1,57,680                            | 1,752                   | 2.12                                | 0.03                    |
| 20     | STEFINA              | 1,48,920                            | 1,752                   | 2.12                                | 0.03                    |
| 21     | EMBOZA               | 6,04,440                            | 2,628                   | 2.12                                | 0.13                    |
| 22     | ARMANO*              | 4,91,436                            | 7,008                   | 2.12                                | 0.10                    |
| 23     | COLOR*               | 1,55,052                            | 6,132                   | 2.12                                | 0.03                    |
| 24     | ASTRON EXPRESS       | 1,84,836                            | 1,752                   | 2.12                                | 0.04                    |
| 25     | LIVA IND.            | 1,23,516                            | 876                     | 2.12                                | 0.03                    |
| 26     | SANSKAR              | 1,81,332                            | 876                     | 2.12                                | 0.04                    |
| 27     | ELECTROMELT          | 4,04,712                            | -                       | 2.12                                | 0.09                    |
| 28     | 11 kV Vallabh Ispat  | 2,08,488                            | 876                     | 2.12                                | 0.04                    |
| 29     | SARDAR               | 1,33,152                            | 876                     | 2.12                                | 0.03                    |
| 30     | 11 kV Krishna Ispat  | 67,452                              | -                       | 2.12                                | 0.01                    |
| 31     | 11 kV Vallabh Alloys | 29,784                              | -                       | 2.12                                | 0.01                    |
| 32     | 11 kV KAG            | 34,164                              | -                       | 2.12                                | 0.01                    |
| 33     | 11 kV Admin          | 4,380                               | 876                     | 2.12                                | 0.00                    |

Table 79 - Annual saving due to conversion into 66 kV for feeders in Group A – PGCVL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name   | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|---------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11 kV Aajveto | 1,470                                | 1.03                                | 5.30                              | 6.33                                        |
| 2      | JETPAR JGY*   | 1,470                                | 1.03                                | 1.22                              | 2.25                                        |
| 3      | ITALUS IND.*  | 420                                  | 1.01                                | 1.02                              | 2.02                                        |
| 4      | 11 kV Lakme   | 1,470                                | 1.03                                | 5.49                              | 6.52                                        |
| 5      | 11 kV Milano  | 420                                  | 1.01                                | 5.12                              | 6.13                                        |
| 6      | 11 kV Aditya  | 420                                  | 1.01                                | 4.72                              | 5.72                                        |
| 7      | 11 kV Falcon* | 640                                  | 1.01                                | 0.94                              | 1.95                                        |

| Sl No. | Feeder Name          | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|----------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 8      | AJANTA               | 1,470                                | 1.03                                | 10.58                             | 11.61                                       |
| 9      | 11 kV Shakti Ind     | 1,470                                | 1.03                                | 4.99                              | 6.02                                        |
| 10     | 11 kV Narmada        | 420                                  | 1.01                                | 4.38                              | 5.39                                        |
| 11     | 11KV KT MILL EXP     | 420                                  | 1.01                                | 16.89                             | 17.90                                       |
| 12     | ARIHANT FEEDER       | 420                                  | 1.01                                | 6.96                              | 7.97                                        |
| 13     | 11 kV Varmora        | 420                                  | 1.01                                | 4.57                              | 5.58                                        |
| 14     | 11 kV Lemorex        | 1,470                                | 1.03                                | 4.75                              | 5.78                                        |
| 15     | EURO                 | 1,470                                | 1.03                                | 6.87                              | 7.90                                        |
| 16     | 11 kV Vishnu         | 1,470                                | 1.03                                | 4.75                              | 5.78                                        |
| 17     | MADHAV METCAST       | 1,130                                | 1.02                                | 9.64                              | 10.66                                       |
| 18     | 11 kV Clan           | 420                                  | 1.01                                | 4.88                              | 5.89                                        |
| 19     | STEFINA              | 1,470                                | 1.03                                | 8.34                              | 9.37                                        |
| F20    | STEFINA              | 1,470                                | 1.03                                | 7.97                              | 9.00                                        |
| 21     | EMBOZA               | 420                                  | 1.01                                | 7.77                              | 8.78                                        |
| 22     | ARMANO*              | 1,470                                | 1.03                                | 1.06                              | 2.09                                        |
| 23     | COLOR*               | 1,470                                | 1.03                                | 1.09                              | 2.12                                        |
| 24     | ASTRON EXPRESS       | 420                                  | 1.01                                | 8.62                              | 9.62                                        |
| 25     | LIVA IND.            | 1,470                                | 1.03                                | 6.68                              | 7.71                                        |
| 26     | SANSKAR              | 1,470                                | 1.03                                | 7.02                              | 8.04                                        |
| 27     | ELECTROMELT          | 840                                  | 1.02                                | 11.93                             | 12.94                                       |
| 28     | 11 kV Vallabh Ispat  | 810                                  | 1.02                                | 5.80                              | 6.82                                        |
| 29     | SARDAR               | 840                                  | 1.02                                | 10.09                             | 11.10                                       |
| 30     | 11 kV Krishna Ispat  | 1,130                                | 1.02                                | 5.86                              | 6.88                                        |
| 31     | 11 kV Vallabh Alloys | 160                                  | 1.00                                | 5.30                              | 6.31                                        |
| 32     | 11 kV KAG            | 1,470                                | 1.03                                | 5.51                              | 6.53                                        |
| 33     | 11 kV Admin          | 1,470                                | 1.03                                | 4.97                              | 6.00                                        |

Table 80 - Conversion cost for supply at 66kV level for feeders in Group A – PGCVL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name          | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|----------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kV Aajveto        | 6.33                                        | 0.30                    | 21                     |
| 2      | JETPAR JGY*          | 2.25                                        | 0.19                    | 12                     |
| 3      | ITALUS IND.*         | 2.02                                        | 0.17                    | 12                     |
| 4      | 11 kV Lakme          | 6.52                                        | 0.28                    | 23                     |
| 5      | 11 kV Milano         | 6.13                                        | 0.10                    | 63                     |
| 6      | 11 kV Aditya         | 5.72                                        | 0.16                    | 35                     |
| 7      | 11 kV Falcon*        | 1.95                                        | 0.19                    | 10                     |
| 8      | AJANTA               | 11.61                                       | 0.12                    | 96                     |
| 9      | 11 kV Shakti Ind     | 6.02                                        | 0.09                    | 67                     |
| 10     | 11 kV Narmada        | 5.39                                        | 0.12                    | 46                     |
| 11     | 11KV KT MILL EXP     | 17.90                                       | 0.15                    | 119                    |
| 12     | ARIHANT FEEDER       | 7.97                                        | 0.11                    | 73                     |
| 13     | 11 kV Varmora        | 5.58                                        | 0.20                    | 27                     |
| 14     | 11 kV Lemorex        | 5.78                                        | 0.02                    | 234                    |
| 15     | EURO                 | 7.90                                        | 0.02                    | 322                    |
| 16     | 11 kV Vishnu         | 5.78                                        | 0.08                    | 72                     |
| 17     | MADHAV METCAST       | 10.66                                       | 0.08                    | 131                    |
| 18     | 11 kV Clan           | 5.89                                        | 0.03                    | 180                    |
| 19     | STEFINA              | 9.37                                        | 0.03                    | 283                    |
| 20     | STEFINA              | 9.00                                        | 0.03                    | 288                    |
| 21     | EMBOZA               | 8.78                                        | 0.13                    | 69                     |
| 22     | ARMANO*              | 2.09                                        | 0.10                    | 20                     |
| 23     | COLOR*               | 2.12                                        | 0.03                    | 67                     |
| 24     | ASTRON EXPRESS       | 9.62                                        | 0.04                    | 248                    |
| 25     | LIVA IND.            | 7.71                                        | 0.03                    | 297                    |
| 26     | SANSKAR              | 8.04                                        | 0.04                    | 210                    |
| 27     | ELECTROMELT          | 12.94                                       | 0.09                    | 151                    |
| 28     | 11 kV Vallabh Ispat  | 6.82                                        | 0.04                    | 155                    |
| 29     | SARDAR               | 11.10                                       | 0.03                    | 396                    |
| 30     | 11 kV Krishna Ispat  | 6.88                                        | 0.01                    | 481                    |
| 31     | 11 kV Vallabh Alloys | 6.31                                        | 0.01                    | 999                    |
| 32     | 11 kV KAG            | 6.53                                        | 0.01                    | 902                    |
| 33     | 11 kV Admin          | 6.00                                        | 0.00                    | 8,079                  |

Table 81 - Payback period for conversion to 66 kV for feeders in Group A – PGCVL

\* Conversion on 66 kV overhead line on ACSR Dog conductor

## Analysis of 11 kV feeders on 55 mm<sup>2</sup> AAAC Rabbit conductors – Group B

### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name        | Length (ckt km) | Consumer Name       | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|--------------------|-----------------|---------------------|-----------------------|----------------------------|-------------|
| 1      | SWASTIK IND. FEED. | 4.00            | M/S. GRV Spintex    | 2300                  | 1,86,98,840                | 98%         |
| 2      | MICRON IND         | 4.75            | A AND J MICRONS     | 3000                  | 2,54,35,740                | 97%         |
| 3      | LEASPIN            | 3.80            | M/S LEASPIN         | 2800                  | 1,18,61,980                | 82%         |
| 4      | TSPL               | 4.50            | TRIBHUVAN SPINT     | 3000                  | 2,18,93,760                | 80%         |
| 5      | RADHE LAXMI        | 3.50            | M/S RADHALAXMI      | 3100                  | 1,90,04,850                | 76%         |
| 6      | 11 kV Rosa         | 2.50            | Renite Vitrified    | 2800                  | 90,88,313                  | 74%         |
| 7      | 11 kV Tirth        | 2.60            | Tirth Agro          | 2500                  | 1,98,13,140                | 72%         |
| 8      | 11KV AASTHA        | 7.50            | AASTHA SPINTEX      | 3000                  | 2,12,73,000                | 70%         |
| 9      | SOLOGRES           | 4.10            | M/S SOLOGRES        | 2600                  | 1,52,02,600                | 65%         |
| 10     | 11KV ASHAPURA      | 7.44            | M/S ASHAPURA INT    | 2800                  | 1,40,66,880                | 63%         |
| 11     | MARUTI IND         | 4.10            | M/S.MARUTI SPINT    | 2900                  | 1,51,99,188                | 58%         |
| 12     | 11 kV Arya         | 2.66            | Arya Metalcast      | 4000                  | 1,15,70,640                | 55%         |
| 13     | 11 kV Granoland    | 2.50            | Granoland Tiles     | 2800                  | 1,16,04,030                | 54%         |
| 14     | 11 kV Nice         | 2.30            | Nice Ceramics       | 2700                  | 79,72,140                  | 51%         |
| 15     | 11 kV Commander    | 2.42            | Commander Vitrified | 3800                  | 1,44,31,700                | 47%         |
| 16     | VISHAL             | 11.20           | M/S VISHAL MANUF    | 2500                  | 37,65,764                  | 19%         |
| 17     | SLIM IND           | 3.41            | M/S. SLIMLITE       | 2500                  | 44,69,600                  | 18%         |

Table 82 - Basic details of feeders in Group B - PGVCL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional  $I^2R$  method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name        | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|--------------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | SWASTIK IND. FEED. | 56          | 0.971            | 8.676                           | 27,208                  |
| 2      | MICRON IND         | 140         | 0.950            | 10.303                          | 2,01,934                |
| 3      | LEASPIN            | 110         | 0.702            | 8.242                           | 99,731                  |
| 4      | TSPL               | 104         | 0.670            | 9.761                           | 1,05,570                |
| 5      | RADHE LAXMI        | 92          | 0.617            | 7.592                           | 64,254                  |

| Sl No. | Feeder Name     | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|-----------------|-------------|------------------|---------------------------------|-------------------------|
| 6      | 11 kV Rosa      | 98          | 0.586            | 5.423                           | 52,078                  |
| 7      | 11 kV Tirth     | 160         | 0.561            | 5.639                           | 1,44,369                |
| 8      | 11KV AASTHA     | 98          | 0.532            | 16.268                          | 1,56,233                |
| 9      | SOLOGRES        | 120         | 0.468            | 8.893                           | 1,28,058                |
| 10     | 11KV ASHAPURA   | 53          | 0.443            | 13.861                          | 38,935                  |
| 11     | MARUTI IND      | 161         | 0.381            | 8.893                           | 2,30,513                |
| 12     | 11 kV Arya      | 122         | 0.352            | 5.765                           | 85,809                  |
| 13     | 11 kV Granoland | 72          | 0.346            | 5.423                           | 28,110                  |
| 14     | 11 kV Nice      | 65          | 0.313            | 4.989                           | 21,077                  |
| 15     | 11 kV Commander | 84          | 0.270            | 5.249                           | 37,037                  |
| 16     | VISHAL          | 24          | 0.066            | 20.866                          | 12,019                  |
| 17     | SLIM IND        | 39          | 0.060            | 7.396                           | 11,250                  |

Table 83 - Calculation of peak power losses at 11 kV for feeders in Group B - PGVCL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name        | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|--------------------|-----------------|------------------------|------------------|--------------------|
| 1      | SWASTIK IND. FEED. | 2,31,502        | 1,05,677               | 3,37,179         | 1.8%               |
| 2      | MICRON IND         | 16,80,462       | 1,34,814               | 18,15,276        | 7.1%               |
| 3      | LEASPIN            | 6,13,226        | 92,970                 | 7,06,196         | 6.0%               |
| 4      | TSPL               | 6,19,409        | 95,050                 | 7,14,459         | 3.3%               |
| 5      | RADHE LAXMI        | 3,47,105        | 90,430                 | 4,37,535         | 2.3%               |
| 6      | 11 kV Rosa         | 2,67,370        | 77,627                 | 3,44,997         | 3.8%               |
| 7      | 11 kV Tirth        | 7,09,709        | 66,365                 | 7,76,075         | 3.9%               |
| 8      | 11KV AASTHA        | 7,28,096        | 75,497                 | 8,03,593         | 3.8%               |
| 9      | SOLOGRES           | 5,25,015        | 57,562                 | 5,82,577         | 3.8%               |
| 10     | 11KV ASHAPURA      | 1,51,257        | 58,739                 | 2,09,997         | 1.5%               |
| 11     | MARUTI IND         | 7,68,991        | 52,242                 | 8,21,232         | 5.4%               |
| 12     | 11 kV Arya         | 2,64,595        | 66,604                 | 3,31,199         | 2.9%               |
| 13     | 11 kV Granoland    | 85,246          | 45,852                 | 1,31,098         | 1.1%               |
| 14     | 11 kV Nice         | 57,864          | 40,027                 | 97,891           | 1.2%               |
| 15     | 11 kV Commander    | 87,661          | 48,568                 | 1,36,229         | 0.9%               |
| 16     | VISHAL             | 6,989           | 7,851                  | 14,840           | 0.4%               |

| Sl No. | Feeder Name | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-------------|-----------------|------------------------|------------------|--------------------|
| 17     | SLIM IND    | 5,961           | 7,154                  | 13,115           | 0.3%               |

Table 84 - Technical loss calculation at 11 kV level for feeders in Group B - PGVCL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name        | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|--------------------|------------------------------|-------------------------------|--------------------|
| 1      | SWASTIK IND. FEED. | 34.9                         | 3,05,724                      | 1.6%               |
| 2      | MICRON IND         | 215                          | 18,83,400                     | 7.4%               |
| 3      | LEASPIN            | 77.2                         | 6,76,272                      | 5.7%               |
| 4      | TSPL               | 80.2                         | 7,02,552                      | 3.2%               |
| 5      | RADHE LAXMI        | 52                           | 4,55,520                      | 2.4%               |
| 6      | 11 kV Rosa         | 40.3                         | 3,53,028                      | 3.9%               |
| 7      | 11 kV Tirth        | 89.2                         | 7,81,392                      | 3.9%               |
| 8      | 11KV AASTHA        | 84.7                         | 7,41,972                      | 3.5%               |
| 9      | SOLOGRES           | 67.8                         | 5,93,928                      | 3.9%               |
| 10     | 11KV ASHAPURA      | 18.8                         | 1,64,688                      | 1.2%               |
| 11     | MARUTI IND         | 87.6                         | 7,67,376                      | 5.0%               |
| 12     | 11 kV Arya         | 39                           | 3,41,640                      | 3.0%               |
| 13     | 11 kV Granoland    | 18.2                         | 1,59,432                      | 1.4%               |
| 14     | 11 kV Nice         | 14.9                         | 1,30,524                      | 1.6%               |
| 15     | 11 kV Commander    | 20.8                         | 1,82,208                      | 1.3%               |
| 16     | VISHAL             | 3.6                          | 31,536                        | 0.8%               |
| 17     | SLIM IND           | 2                            | 17,520                        | 0.4%               |

Table 85 - 11 kV loss results from ETAP software for feeders in Group B – PGVCL

### Comparison of ETAP loss with energy audit

Since PGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name        | ETAP Loss (kWh) | ETAP Loss (%) | EA Loss (kWh) | EA Loss (%) |
|--------|--------------------|-----------------|---------------|---------------|-------------|
| 1      | SWASTIK IND. FEED. | 3,05,724        | 1.6%          | -67,752       | -0.4%       |
| 2      | MICRON IND         | 18,83,400       | 7.4%          | 21,60,877     | 8.5%        |
| 3      | LEASPIN            | 6,76,272        | 5.7%          | 6,55,450      | 5.5%        |
| 4      | TSPL               | 7,02,552        | 3.2%          | 6,63,862      | 3.0%        |
| 5      | RADHE LAXMI        | 4,55,520        | 2.4%          | 3,85,470      | 2.0%        |

| Sl No. | Feeder Name     | ETAP Loss (kWh) | ETAP Loss (%) | EA Loss (kWh) | EA Loss (%) |
|--------|-----------------|-----------------|---------------|---------------|-------------|
| 6      | 11 kV Rosa      | 3,53,028        | 3.9%          | 4,00,113      | 4.4%        |
| 7      | 11 kV Tirth     | 7,81,392        | 3.9%          | 5,43,300      | 2.7%        |
| 8      | 11KV AASTHA     | 7,41,972        | 3.5%          | 7,05,647      | 3.3%        |
| 9      | SOLOGRES        | 5,93,928        | 3.9%          | 5,72,606      | 3.8%        |
| 10     | 11KV ASHAPURA   | 1,64,688        | 1.2%          | 1,60,230      | 1.1%        |
| 11     | MARUTI IND      | 7,67,376        | 5.0%          | 7,94,692      | 5.2%        |
| 12     | 11 kV Arya      | 3,41,640        | 3.0%          | 3,81,022      | 3.3%        |
| 13     | 11 kV Granoland | 1,59,432        | 1.4%          | -4,17,906     | -3.6%       |
| 14     | 11 kV Nice      | 1,30,524        | 1.6%          | 69,860        | 0.9%        |
| 15     | 11 kV Commander | 1,82,208        | 1.3%          | 1,98,772      | 1.4%        |
| 16     | VISHAL          | 31,536          | 0.8%          | 19,916        | 0.5%        |
| 17     | SLIM IND        | 17,520          | 0.4%          | 6,22,805      | 13.9%       |

Table 86 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name        | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|--------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | SWASTIK IND. FEED. | 534                   | 0.01%          | 3,504                   | 0.02%                      |
| 2      | MICRON IND         | 3,874                 | 0.02%          | 7,008                   | 0.03%                      |
| 3      | LEASPIN            | 1,414                 | 0.02%          | 1,752                   | 0.02%                      |
| 4      | TSPL               | 1,428                 | 0.02%          | 4,380                   | 0.04%                      |
| 5      | RADHE LAXMI        | 800                   | 0.03%          | 3,504                   | 0.01%                      |
| 6      | 11 kV Rosa         | 616                   | 0.02%          | 876                     | 0.02%                      |
| 7      | 11 kV Tirth        | 1,636                 | 0.02%          | -                       | 0.03%                      |
| 8      | 11KV AASTHA        | 1,678                 | 0.02%          | 7,008                   | 0.01%                      |
| 9      | SOLOGRES           | 1,210                 | 0.01%          | 1,752                   | 0.00%                      |
| 10     | 11KV ASHAPURA      | 406                   | 0.02%          | 3,504                   | 0.00%                      |
| 11     | MARUTI IND         | 1,773                 | 0.01%          | 1,752                   | 0.02%                      |
| 12     | 11 kV Arya         | 610                   | 0.01%          | 876                     | 0.01%                      |
| 13     | 11 kV Granoland    | 197                   | 0.01%          | 876                     | 0.01%                      |

| Sl No. | Feeder Name     | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|-----------------|-----------------------|----------------|-------------------------|----------------------------|
| 14     | 11 kV Nice      | 133                   | 0.01%          | 876                     | 0.01%                      |
| 15     | 11 kV Commander | 202                   | 0.01%          | 876                     | 0.01%                      |
| 16     | VISHAL          | 19                    | 0.00%          | -                       | 0.00%                      |
| 17     | SLIM IND        | 14                    | 0.00%          | -                       | 0.01%                      |

Table 87 - Loss calculation at 66 kV level for feeders in Group B - PGVCL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name        | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|--------------------|-------------------------------------|-------------------------|--------------------------------|-------------------------|
| 1      | SWASTIK IND. FEED. | 3,05,724                            | 3,504                   | 2.12                           | 0.06                    |
| 2      | MICRON IND         | 18,83,400                           | 7,008                   | 2.12                           | 0.40                    |
| 3      | LEASPIN            | 6,76,272                            | 1,752                   | 2.12                           | 0.14                    |
| 4      | TSPL               | 7,02,552                            | 4,380                   | 2.12                           | 0.15                    |
| 5      | RADHE LAXMI        | 4,55,520                            | 3,504                   | 2.12                           | 0.10                    |
| 6      | 11 kV Rosa         | 3,53,028                            | 876                     | 2.12                           | 0.07                    |
| 7      | 11 kV Tirth        | 7,81,392                            | -                       | 2.12                           | 0.17                    |
| 8      | 11KV AASTHA        | 7,41,972                            | 7,008                   | 2.12                           | 0.16                    |
| 9      | SOLOGRES           | 5,93,928                            | 1,752                   | 2.12                           | 0.13                    |
| 10     | 11KV ASHAPURA      | 1,64,688                            | 3,504                   | 2.12                           | 0.03                    |
| 11     | MARUTI IND         | 7,67,376                            | 1,752                   | 2.12                           | 0.16                    |
| 12     | 11 kV Arya         | 3,41,640                            | 876                     | 2.12                           | 0.07                    |
| 13     | 11 kV Granoland    | 1,59,432                            | 876                     | 2.12                           | 0.03                    |
| 14     | 11 kV Nice         | 1,30,524                            | 876                     | 2.12                           | 0.03                    |
| 15     | 11 kV Commander    | 1,82,208                            | 876                     | 2.12                           | 0.04                    |
| 16     | VISHAL             | 31,536                              | -                       | 2.12                           | 0.01                    |
| 17     | SLIM IND           | 17,520                              | -                       | 2.12                           | 0.00                    |

Table 88 - Annual saving due to conversion into 66 kV for feeders in Group B - PGVCL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name        | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|--------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | SWASTIK IND. FEED. | 160                                  | 1.00                                | 7.88                              | 8.88                                        |
| 2      | MICRON IND         | 1,470                                | 1.03                                | 9.26                              | 10.29                                       |
| 3      | LEASPIN            | 1,470                                | 1.03                                | 7.51                              | 8.54                                        |
| 4      | TSPL               | 300                                  | 1.01                                | 8.80                              | 9.81                                        |
| 5      | RADHE LAXMI        | 300                                  | 1.01                                | 6.96                              | 7.97                                        |
| 6      | 11 kV Rosa         | 420                                  | 1.01                                | 5.12                              | 6.13                                        |
| 7      | 11 kV Tirth        | 640                                  | 1.01                                | 5.30                              | 6.32                                        |
| 8      | 11KV AASTHA        | 420                                  | 1.01                                | 14.32                             | 15.33                                       |
| 9      | SOLOGRES           | 1,470                                | 1.03                                | 8.06                              | 9.09                                        |
| 10     | 11KV ASHAPURA      | 300                                  | 1.01                                | 14.21                             | 15.22                                       |
| 11     | MARUTI IND         | 560                                  | 1.01                                | 8.06                              | 9.07                                        |
| 12     | 11 kV Arya         | 6,340                                | 1.12                                | 5.41                              | 6.53                                        |
| 13     | 11 kV Granoland    | 1,470                                | 1.03                                | 5.12                              | 6.15                                        |
| 14     | 11 kV Nice         | 1,470                                | 1.03                                | 4.75                              | 5.78                                        |
| 15     | 11 kV Commander    | 420                                  | 1.01                                | 4.97                              | 5.98                                        |
| 16     | VISHAL             | 9,940                                | 1.19                                | 21.13                             | 22.32                                       |
| 17     | SLIM IND           | 1,470                                | 1.03                                | 6.79                              | 7.82                                        |

Table 89 - Conversion cost for supply at 66kV level for feeders in Group B - PGVCL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name        | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|--------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | SWASTIK IND. FEED. | 8.88                                        | 0.06                    | 139                    |
| 2      | MICRON IND         | 10.29                                       | 0.40                    | 26                     |
| 3      | LEASPIN            | 8.54                                        | 0.14                    | 60                     |
| 4      | TSPL               | 9.81                                        | 0.15                    | 66                     |
| 5      | RADHE LAXMI        | 7.97                                        | 0.10                    | 83                     |
| 6      | 11 kV Rosa         | 6.13                                        | 0.07                    | 82                     |
| 7      | 11 kV Tirth        | 6.32                                        | 0.17                    | 38                     |
| 8      | 11KV AASTHA        | 15.33                                       | 0.16                    | 98                     |
| 9      | SOLOGRES           | 9.09                                        | 0.13                    | 72                     |
| 10     | 11KV ASHAPURA      | 15.22                                       | 0.03                    | 445                    |
| 11     | MARUTI IND         | 9.07                                        | 0.16                    | 56                     |
| 12     | 11 kV Arya         | 6.53                                        | 0.07                    | 90                     |
| 13     | 11 kV Granoland    | 6.15                                        | 0.03                    | 183                    |

| Sl No. | Feeder Name     | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|-----------------|---------------------------------------------|-------------------------|------------------------|
| 14     | 11 kV Nice      | 5.78                                        | 0.03                    | 210                    |
| 15     | 11 kV Commander | 5.98                                        | 0.04                    | 156                    |
| 16     | VISHAL          | 22.32                                       | 0.01                    | 3,339                  |
| 17     | SLIM IND        | 7.82                                        | 0.00                    | 2,106                  |

Table 90 - Payback period for conversion to 66 kV for feeders in Group B - PGVCL

## CHAPTER: 7 ANALYSIS OF SAMPLE FEEDERS - UGVCL

Details of sample feeders chosen for UGVCL area are as follows –

| Group        | Configuration                                                         | Feeder type | Numbers   |
|--------------|-----------------------------------------------------------------------|-------------|-----------|
| Group A      | 11 kV feeders on overhead ACSR Dog conductor (100 mm <sup>2</sup> )   | Express     | 23        |
| Group B      | 11 kV feeders on underground XLPE cables (185 mm <sup>2</sup> )       | Express     | 16        |
| Group C      | 11 kV feeders on overhead ACSR Rabbit conductor (55 mm <sup>2</sup> ) | Express     | 2         |
| <b>Total</b> |                                                                       |             | <b>41</b> |

Table 91 - Classification of sample feeders - UGVCL

Each of these feeder types are analysed in separate groups in subsequent sections of this chapter.

### Analysis of 11 kV feeders on 100 mm<sup>2</sup> ACSR Dog Conductor – Group A

#### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name       | Length (ckt km) | Consumer Name                      | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|-------------------|-----------------|------------------------------------|-----------------------|----------------------------|-------------|
| 1      | Bhagwati          | 3.04            | M/S BHAGWATI AUTO CAST LTD.        | 2200                  | 1,67,22,689                | 93%         |
| 2      | 11 kV Nandeshwari | 2.44            | Nandeshwari Steel                  | 4000                  | 2,25,35,211                | 90%         |
| 3      | 11 kV C M Smith   | 2.34            | CM Smith                           | 4000                  | 2,66,83,563                | 82%         |
| 4      | 11 kV Dairy       | 2.30            | Mehsana Dist Coop                  | 3200                  | 2,09,64,446                | 81%         |
| 5      | VADILAL IND       | 5.00            | M.S. VADILAL IND. LTD.             | 3500                  | 1,85,91,443                | 80%         |
| 6      | GUNINA            | 1.00            | M/S GUNINA ALLOY & STEEL PVT. LTD. | 4000                  | 1,00,95,295                | 71%         |
| 7      | MIT               | 1.50            | M/S MIT IRON & STEEL PVT. LTD.     | 3700                  | 91,64,312                  | 71%         |
| 8      | VIJAPUR METALS    | 3.00            | M/S VIJAPUR METALS P.LTD           | 4000                  | 1,06,32,470                | 68%         |

| Sl No. | Feeder Name           | Length (ckt km) | Consumer Name             | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|-----------------------|-----------------|---------------------------|-----------------------|----------------------------|-------------|
| 9      | ISPAT                 | 4.00            | M/S A. I. ISPAT PVT. LTD. | 3900                  | 1,11,95,335                | 65%         |
| 10     | SHYAMSUNDAR(EXP)      | 6.68            | M/S SHREE SHYAMSUNDER     | 2900                  | 55,06,300                  | 52%         |
| 11     | 11 kV GWSSB           | 2.30            | Lubi Industries           | 3500                  | 46,18,809                  | 51%         |
| 12     | Nami                  | 5.00            | M/S NAMI STEEL PVT. LTD.  | 3900                  | 1,25,43,962                | 40%         |
| 13     | 11 kV Sandvik Asia    | 2.20            | Sandvik Asia              | 3300                  | 1,06,08,553                | 39%         |
| 14     | 11 kV Swastik Concast | 2.86            | Swastik Ceracon           | 2700                  | 35,71,429                  | 37%         |
| 15     | Someswar              | 3.20            | SOMESHWAR ISPAT PVT LTD.  | 2600                  | 77,48,691                  | 36%         |
| 16     | UMIYA METAL           | 0.80            | M/S UMIYA METALS P.LTD.   | 3500                  | 92,62,048                  | 33%         |
| 17     | Kalana                | 1.60            | KALANA ISPAT PVT. LTD.    | 3700                  | 92,77,294                  | 31%         |
| 18     | 11 kV Shaifali        | 2.00            | Shaifali Steel            | 2500                  | 61,44,393                  | 31%         |
| 19     | 11 kV Gopi            | 2.50            | Gopi Steel                | 3100                  | 5,00,00,000                | 29%         |
| 20     | Grace                 | 1.75            | M/S GRACE CASTING LTD.    | 4000                  | 81,64,766                  | 27%         |
| 21     | Ramdev                | 1.90            | GRACE CASTINGS LTD.       | 2400                  | 46,97,024                  | 26%         |
| 22     | ASHRAM HT EXPRESS     | 0.99            | M/S UMIYA CAST LLP.       | 4000                  | 11,66,407                  | 4%          |
| 23     | CANAL HT EXP.         | 6.20            | EE DRAINAGE GANDHINAGAR   | 2300                  | 6,55,380                   | 4%          |

Table 92 - Basic details of feeders in Group A - UGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional  $I^2R$  method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name       | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|-------------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | Bhagwati          | 118         | 0.879            | 3.576                           | 49,797                  |
| 2      | 11 kV Nandeshwari | 170         | 0.828            | 2.875                           | 83,079                  |
| 3      | 11 kV C M Smith   | 230         | 0.707            | 2.757                           | 1,45,845                |
| 4      | 11 kV Dairy       | 174         | 0.687            | 2.708                           | 81,974                  |
| 5      | VADILAL IND       | 130         | 0.672            | 5.886                           | 99,473                  |

| Sl No. | Feeder Name           | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|-----------------------|-------------|------------------|---------------------------------|-------------------------|
| 6      | GUNINA                | 198         | 0.545            | 1.177                           | 46,151                  |
| 7      | MIT                   | 124         | 0.545            | 1.766                           | 27,151                  |
| 8      | VIJAPUR METALS        | 128         | 0.506            | 3.532                           | 57,862                  |
| 9      | ISPAT                 | 120         | 0.468            | 4.709                           | 67,807                  |
| 10     | SHYAMSUNDAR(EXP)      | 71          | 0.324            | 7.864                           | 39,641                  |
| 11     | 11 kV GWSSB           | 65          | 0.315            | 2.708                           | 11,439                  |
| 12     | Nami                  | 166         | 0.211            | 5.886                           | 1,62,195                |
| 13     | 11 kV Sandvik Asia    | 166         | 0.200            | 2.590                           | 71,366                  |
| 14     | 11 kV Swastik Concast | 130         | 0.180            | 3.367                           | 56,899                  |
| 15     | Someswar              | 160         | 0.174            | 3.764                           | 96,346                  |
| 16     | UMIYA METAL           | 186         | 0.155            | 0.942                           | 32,581                  |
| 17     | Kalana                | 191         | 0.140            | 1.884                           | 68,713                  |
| 18     | 11 kV Shaifali        | 154         | 0.137            | 2.354                           | 55,837                  |
| 19     | 11 kV Gopi            | 160         | 0.123            | 2.943                           | 75,341                  |
| 20     | Grace                 | 201         | 0.110            | 2.060                           | 83,230                  |
| 21     | Ramdev                | 29          | 0.103            | 2.237                           | 1,881                   |
| 22     | ASHRAM HT EXPRESS     | 228         | 0.009            | 1.160                           | 60,278                  |
| 23     | CANAL HT EXP.         | 95          | 0.008            | 7.299                           | 65,870                  |

Table 93 - Calculation of peak power losses at 11 kV for feeders in Group A - UGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name       | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-------------------|-----------------|------------------------|------------------|--------------------|
| 1      | Bhagwati          | 3,83,224        | 91,426                 | 4,74,650         | 2.8%               |
| 2      | 11 kV Nandeshwari | 6,02,599        | 1,56,671               | 7,59,270         | 3.4%               |
| 3      | 11 kV C M Smith   | 9,02,952        | 1,33,729               | 10,36,681        | 3.9%               |
| 4      | 11 kV Dairy       | 4,93,390        | 1,04,006               | 5,97,396         | 2.8%               |
| 5      | VADILAL IND       | 5,85,572        | 1,11,259               | 6,96,831         | 3.7%               |
| 6      | GUNINA            | 2,20,447        | 1,03,176               | 3,23,623         | 3.2%               |
| 7      | MIT               | 1,29,691        | 95,438                 | 2,25,128         | 2.5%               |
| 8      | VIJAPUR METALS    | 2,56,435        | 95,728                 | 3,52,163         | 3.3%               |
| 9      | ISPAT             | 2,77,986        | 86,339                 | 3,64,325         | 3.3%               |
| 10     | SHYAMSUNDAR(EXP)  | 1,12,395        | 44,401                 | 1,56,796         | 2.8%               |

| Sl No. | Feeder Name           | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-----------------------|-----------------|------------------------|------------------|--------------------|
| 11     | 11 kV GWSSB           | 31,525          | 52,085                 | 83,611           | 1.8%               |
| 12     | Nami                  | 3,00,452        | 39,012                 | 3,39,464         | 2.7%               |
| 13     | 11 kV Sandvik Asia    | 1,24,773        | 31,156                 | 1,55,929         | 1.5%               |
| 14     | 11 kV Swastik Concast | 89,594          | 22,958                 | 1,12,552         | 3.2%               |
| 15     | Someswar              | 1,46,894        | 21,406                 | 1,68,300         | 2.2%               |
| 16     | UMIYA METAL           | 44,154          | 25,613                 | 69,767           | 0.8%               |
| 17     | Kalana                | 84,343          | 24,525                 | 1,08,868         | 1.2%               |
| 18     | 11 kV Shaifali        | 66,782          | 16,146                 | 82,928           | 1.3%               |
| 19     | 11 kV Gopi            | 81,455          | 18,099                 | 99,554           | 0.2%               |
| 20     | Grace                 | 79,998          | 20,761                 | 1,00,760         | 1.2%               |
| 21     | Ramdev                | 1,702           | 11,729                 | 13,432           | 0.3%               |
| 22     | ASHRAM HT EXPRESS     | 4,697           | 1,683                  | 6,380            | 0.5%               |
| 23     | CANAL HT EXP.         | 4,768           | 899                    | 5,667            | 0.9%               |

Table 94 - Technical loss calculation at 11 kV level for feeders in Group A - UGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name           | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|-----------------------|------------------------------|-------------------------------|--------------------|
| 1      | Bhagwati              | 51.5                         | 4,51,140                      | 2.7%               |
| 2      | 11 kV Nandeshwari     | 85.3                         | 7,47,228                      | 3.3%               |
| 3      | 11 kV C M Smith       | 131.1                        | 11,48,436                     | 4.3%               |
| 4      | 11 kV Dairy           | 64.8                         | 5,67,648                      | 2.7%               |
| 5      | VADILAL IND           | 82.4                         | 7,21,824                      | 3.9%               |
| 6      | GUNINA                | 37.6                         | 3,29,376                      | 3.3%               |
| 7      | MIT                   | 24.6                         | 2,15,496                      | 2.4%               |
| 8      | VIJAPUR METALS        | 42.4                         | 3,71,424                      | 3.5%               |
| 9      | ISPAT                 | 51.1                         | 4,47,636                      | 4.0%               |
| 10     | SHYAMSUNDAR(EXP)      | 18.1                         | 1,58,556                      | 2.9%               |
| 11     | 11 kV GWSSB           | 7.8                          | 68,328                        | 1.5%               |
| 12     | Nami                  | 40.2                         | 3,52,152                      | 2.8%               |
| 13     | 11 kV Sandvik Asia    | 14.8                         | 1,29,648                      | 1.2%               |
| 14     | 11 kV Swastik Concast | 12.3                         | 1,07,748                      | 3.0%               |
| 15     | Someswar              | 19.4                         | 1,69,944                      | 2.2%               |
| 16     | UMIYA METAL           | 5.6                          | 49,056                        | 0.5%               |
| 17     | Kalana                | 15.8                         | 1,38,408                      | 1.5%               |
| 18     | 11 kV Shaifali        | 7.9                          | 69,204                        | 1.1%               |

| Sl No. | Feeder Name       | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|-------------------|------------------------------|-------------------------------|--------------------|
| 19     | 11 kV Gopi        | 7.7                          | 67,452                        | 0.1%               |
| 20     | Grace             | 8.3                          | 72,708                        | 0.9%               |
| 21     | Ramdev            | 3                            | 26,280                        | 0.6%               |
| 22     | ASHRAM HT EXPRESS | 0.1                          | 876                           | 0.1%               |
| 23     | CANAL HT EXP.     | 0.2                          | 1,752                         | 0.3%               |

Table 95 - 11 kV loss results from ETAP software for feeders in Group A – UGCVL

### Comparison of ETAP loss with energy audit

Since UGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name           | ETAP Loss (kWh) | ETAP Loss (%) | EA Loss (kWh) | EA Loss (%) |
|--------|-----------------------|-----------------|---------------|---------------|-------------|
| 1      | Bhagwati              | 4,51,140        | 2.7%          | 5,97,000      | 3.6%        |
| 2      | 11 kV Nandeshwari     | 7,47,228        | 3.3%          | 6,08,000      | 2.7%        |
| 3      | 11 kV C M Smith       | 11,48,436       | 4.3%          | 7,37,000      | 2.8%        |
| 4      | 11 kV Dairy           | 5,67,648        | 2.7%          | 5,13,000      | 2.4%        |
| 5      | VADILAL IND           | 7,21,824        | 3.9%          | 4,91,000      | 2.6%        |
| 6      | GUNINA                | 3,29,376        | 3.3%          | 3,39,000      | 3.4%        |
| 7      | MIT                   | 2,15,496        | 2.4%          | 2,27,000      | 2.5%        |
| 8      | VIJAPUR METALS        | 3,71,424        | 3.5%          | 4,27,000      | 4.0%        |
| 9      | ISPAT                 | 4,47,636        | 4.0%          | 3,84,000      | 3.4%        |
| 10     | SHYAMSUNDAR(EXP)      | 1,58,556        | 2.9%          | 1,18,000      | 2.1%        |
| 11     | 11 kV GWSSB           | 68,328          | 1.5%          | 83,000        | 1.8%        |
| 12     | Nami                  | 3,52,152        | 2.8%          | 1,07,000      | 0.9%        |
| 13     | 11 kV Sandvik Asia    | 1,29,648        | 1.2%          | 1,29,000      | 1.2%        |
| 14     | 11 kV Swastik Concast | 1,07,748        | 3.0%          | 60,000        | 1.7%        |
| 15     | Someswar              | 1,69,944        | 2.2%          | 1,48,000      | 1.9%        |
| 16     | UMIYA METAL           | 49,056          | 0.5%          | 1,23,000      | 1.3%        |
| 17     | Kalana                | 1,38,408        | 1.5%          | 1,81,000      | 2.0%        |
| 18     | 11 kV Shaifali        | 69,204          | 1.1%          | 40,000        | 0.7%        |
| 19     | 11 kV Gopi            | 67,452          | 0.1%          | 5,000         | 0.0%        |
| 20     | Grace                 | 72,708          | 0.9%          | -2,22,000     | -2.7%       |
| 21     | Ramdev                | 26,280          | 0.6%          | -1,31,000     | -2.8%       |

| Sl No. | Feeder Name       | ETAP Loss (kWh) | ETAP Loss (%) | EA Loss (kWh) | EA Loss (%) |
|--------|-------------------|-----------------|---------------|---------------|-------------|
| 22     | ASHRAM HT EXPRESS | 876             | 0.1%          | -15,000       | -1.3%       |
| 23     | CANAL HT EXP.     | 1,752           | 0.3%          | 12,000        | 1.8%        |

Table 96 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below -

| Sl No. | Feeder Name           | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|-----------------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | Bhagwati              | 1,628                 | 0.01%          | 1,752                   | 0.02%                      |
| 2      | 11 kV Nandeshwari     | 2,559                 | 0.02%          | 3,504                   | 0.02%                      |
| 3      | 11 kV C M Smith       | 3,835                 | 0.01%          | 4,380                   | 0.01%                      |
| 4      | 11 kV Dairy           | 2,096                 | 0.02%          | 2,628                   | 0.01%                      |
| 5      | VADILAL IND           | 2,487                 | 0.02%          | 4,380                   | 0.02%                      |
| 6      | GUNINA                | 936                   | 0.00%          | -                       | 0.01%                      |
| 7      | MIT                   | 551                   | 0.01%          | -                       | 0.01%                      |
| 8      | VIJAPUR METALS        | 7,123                 | 0.01%          | 3,504                   | 0.02%                      |
| 9      | ISPAT                 | 1,181                 | 0.01%          | 876                     | 0.01%                      |
| 10     | SHYAMSUNDAR(EXP)      | 477                   | 0.03%          | 2,628                   | 0.02%                      |
| 11     | 11 kV GWSSB           | 876                   | 0.01%          | 6,132                   | 0.01%                      |
| 12     | Nami                  | 1,276                 | 0.07%          | 1,752                   | 0.04%                      |
| 13     | 11 kV Sandvik Asia    | 530                   | 0.06%          | 2,628                   | 0.03%                      |
| 14     | 11 kV Swastik Concast | 381                   | 0.01%          | 876                     | 0.01%                      |
| 15     | Someswar              | 624                   | 0.01%          | 876                     | 0.00%                      |
| 16     | UMIYA METAL           | 188                   | 0.00%          | -                       | 0.00%                      |
| 17     | Kalana                | 358                   | 0.00%          | -                       | 0.00%                      |
| 18     | 11 kV Shaifali        | 284                   | 0.00%          | -                       | 0.00%                      |
| 19     | 11 kV Gopi            | 2,263                 | 0.00%          | 1,752                   | 0.00%                      |
| 20     | Grace                 | 340                   | 0.00%          | -                       | 0.00%                      |
| 21     | Ramdev                | 7                     | 0.00%          | -                       | 0.00%                      |
| 22     | ASHRAM HT EXPRESS     | 20                    | 0.00%          | -                       | 0.00%                      |
| 23     | CANAL HT EXP.         | 20                    | 0.00%          | -                       | 0.00%                      |

Table 97 - Loss calculation at 66 kV level for feeders in Group A - UGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name           | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|-----------------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | Bhagwati              | 4,51,140                            | 1,628                   | 2.12                                | 0.10                    |
| 2      | 11 kV Nandeshwari     | 7,47,228                            | 2,559                   | 2.12                                | 0.16                    |
| 3      | 11 kV C M Smith       | 11,48,436                           | 3,835                   | 2.12                                | 0.24                    |
| 4      | 11 kV Dairy           | 5,67,648                            | 2,096                   | 2.12                                | 0.12                    |
| 5      | VADILAL IND           | 7,21,824                            | 2,487                   | 2.12                                | 0.15                    |
| 6      | GUNINA                | 3,29,376                            | 936                     | 2.12                                | 0.07                    |
| 7      | MIT                   | 2,15,496                            | 551                     | 2.12                                | 0.05                    |
| 8      | VIJAPUR METALS        | 3,71,424                            | 7,123                   | 2.12                                | 0.08                    |
| 9      | ISPAT                 | 4,47,636                            | 1,181                   | 2.12                                | 0.09                    |
| 10     | SHYAMSUNDAR(EXP)      | 1,58,556                            | 477                     | 2.12                                | 0.03                    |
| 11     | 11 kV GWSSB           | 68,328                              | 876                     | 2.12                                | 0.01                    |
| 12     | Nami                  | 3,52,152                            | 1,276                   | 2.12                                | 0.07                    |
| 13     | 11 kV Sandvik Asia    | 1,29,648                            | 530                     | 2.12                                | 0.03                    |
| 14     | 11 kV Swastik Concast | 1,07,748                            | 381                     | 2.12                                | 0.02                    |
| 15     | Someswar              | 1,69,944                            | 624                     | 2.12                                | 0.04                    |
| 16     | UMIYA METAL           | 49,056                              | 188                     | 2.12                                | 0.01                    |
| 17     | Kalana                | 1,38,408                            | 358                     | 2.12                                | 0.03                    |
| 18     | 11 kV Shaifali        | 69,204                              | 284                     | 2.12                                | 0.01                    |
| 19     | 11 kV Gopi            | 67,452                              | 2,263                   | 2.12                                | 0.01                    |
| 20     | Grace                 | 72,708                              | 340                     | 2.12                                | 0.02                    |
| 21     | Ramdev                | 26,280                              | 7                       | 2.12                                | 0.01                    |
| 22     | ASHRAM HT EXPRESS     | 876                                 | 20                      | 2.12                                | 0.00                    |
| 23     | CANAL HT EXP.         | 1,752                               | 20                      | 2.12                                | 0.00                    |

Table 98 - Annual saving due to conversion into 66 kV for feeders in Group A - UGCVL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name           | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|-----------------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | Bhagwati              | 620                                  | 1.01                                | 6.11                              | 7.12                                        |
| 2      | 11 kV Nandeshwari     | 5,530                                | 1.11                                | 5.01                              | 6.12                                        |
| 3      | 11 kV C M Smith       | 3,230                                | 1.06                                | 4.83                              | 5.89                                        |
| 4      | 11 kV Dairy           | 2,590                                | 1.05                                | 4.75                              | 5.80                                        |
| 5      | VADILAL IND           | 490                                  | 1.01                                | 9.72                              | 10.73                                       |
| 6      | GUNINA                | 840                                  | 1.02                                | 2.36                              | 3.38                                        |
| 7      | MIT                   | 5,280                                | 1.10                                | 3.28                              | 4.38                                        |
| 8      | VIJAPUR METALS*       | 520                                  | 1.01                                | 0.97                              | 1.98                                        |
| 9      | ISPAT                 | 1,470                                | 1.03                                | 7.88                              | 8.91                                        |
| 10     | SHYAMSUNDAR(EXP)      | 5,300                                | 1.10                                | 12.81                             | 13.91                                       |
| 11     | 11 kV GWSSB*          | 5,300                                | 1.10                                | 0.87                              | 1.97                                        |
| 12     | Nami                  | 5,280                                | 1.10                                | 9.72                              | 10.82                                       |
| 13     | 11 kV Sandvik Asia*   | 840                                  | 1.02                                | 0.85                              | 1.87                                        |
| 14     | 11 kV Swastik Concast | 620                                  | 1.01                                | 5.78                              | 6.79                                        |
| 15     | Someswar              | 2,590                                | 1.05                                | 6.40                              | 7.45                                        |
| 16     | UMIYA METAL           | 520                                  | 1.01                                | 1.99                              | 3.00                                        |
| 17     | Kalana                | 5,280                                | 1.10                                | 3.46                              | 4.57                                        |
| 18     | 11 kV Shaifali        | 330                                  | 1.01                                | 4.20                              | 5.21                                        |
| 19     | 11 kV Gopi*           | 540                                  | 1.01                                | 0.90                              | 1.91                                        |
| 20     | Grace                 | 680                                  | 1.01                                | 3.74                              | 4.75                                        |
| 21     | Ramdev                | 840                                  | 1.02                                | 4.02                              | 5.03                                        |
| 22     | ASHRAM HT EXPRESS     | 520                                  | 1.01                                | 2.33                              | 3.34                                        |
| 23     | CANAL HT EXP.         | 3,230                                | 1.06                                | 11.93                             | 12.99                                       |

Table 99 - Conversion cost for supply at 66kV level for feeders in Group A – UGCVL

\* Consumers connected on ASCR Dog conductor

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name       | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|-------------------|---------------------------------------------|-------------------------|------------------------|
| 1      | Bhagwati          | 7.12                                        | 0.18                    | 75                     |
| 2      | 11 kV Nandeshwari | 6.12                                        | 0.30                    | 39                     |
| 3      | 11 kV C M Smith   | 5.89                                        | 0.19                    | 24                     |
| 4      | 11 kV Dairy       | 5.80                                        | 0.19                    | 48                     |

| Sl No. | Feeder Name           | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|-----------------------|---------------------------------------------|-------------------------|------------------------|
| 5      | VADILAL IND           | 10.73                                       | 0.10                    | 71                     |
| 6      | GUNINA                | 3.38                                        | 0.16                    | 48                     |
| 7      | MIT                   | 4.38                                        | 0.24                    | 96                     |
| 8      | VIJAPUR METALS*       | 1.98                                        | 0.12                    | 25                     |
| 9      | ISPAT                 | 8.91                                        | 0.15                    | 94                     |
| 10     | SHYAMSUNDAR(EXP)      | 13.91                                       | 0.07                    | 421                    |
| 11     | 11 kV GWSSB*          | 1.97                                        | 0.05                    | 149                    |
| 12     | Nami                  | 10.82                                       | 0.08                    | 146                    |
| 13     | 11 kV Sandvik Asia*   | 1.87                                        | 0.09                    | 69                     |
| 14     | 11 kV Swastik Concast | 6.79                                        | 0.03                    | 300                    |
| 15     | Someswar              | 7.45                                        | 0.01                    | 208                    |
| 16     | UMIYA METAL           | 3.00                                        | 0.07                    | 289                    |
| 17     | Kalana                | 4.57                                        | 0.03                    | 156                    |
| 18     | 11 kV Shaifali        | 5.21                                        | 0.02                    | 355                    |
| 19     | 11 kV Gopi*           | 1.91                                        | 0.04                    | 137                    |
| 20     | Grace                 | 4.75                                        | 0.01                    | 308                    |
| 21     | Ramdev                | 5.03                                        | 0.03                    | 903                    |
| 22     | ASHRAM HT EXPRESS     | 3.34                                        | 0.01                    | 17,998                 |
| 23     | CANAL HT EXP.         | 12.99                                       | 0.01                    | 34,975                 |

Table 100 - Payback period for conversion to 66 kV for feeders in Group A - UGCVL

## Analysis of 11 kV feeders on 185 mm<sup>2</sup> XLPE underground cables – Group B

### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name | Length (ckt km) | Consumer Name                | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|-------------|-----------------|------------------------------|-----------------------|----------------------------|-------------|
| 1      | 11 kV Abeer | 2.70            | Abeer Textile – II           | 2000                  | 2,92,63,914                | 99%         |
| 2      | Kikani      | 0.55            | KIKANI EXPORTS PVT. LTD.     | 3300                  | 2,51,12,108                | 97%         |
| 3      | 11 KV ACHAL | 1.70            | M/s Achal Spinning Pvt. Ltd. | 4000                  | 2,94,11,765                | 92%         |
| 4      | Vivekanand  | 1.20            | VIVEKANAND COTSPIN LLP       | 2500                  | 1,77,28,532                | 90%         |
| 5      | 11 KV ANMOL | 1.50            | Anmol Spintex Pvt. Ltd.      | 4000                  | 2,69,91,970                | 84%         |
| 6      | VENUS       | 7.00            | M/S GARRISION ENGINEER       | 2000                  | 76,39,539                  | 81%         |

| Sl No. | Feeder Name | Length (ckt km) | Consumer Name              | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|-------------|-----------------|----------------------------|-----------------------|----------------------------|-------------|
| 7      | AMITARA     | 8.20            | AMITARA OVERSEAS LIMITED   | 3200                  | 2,07,91,457                | 80%         |
| 8      | Ajay Ind    | 1.05            | AJAY COTSPIN INDUSTRIES    | 2500                  | 1,49,79,757                | 75%         |
| 9      | Guala       | 3.80            | M/S GUALA COLSURE          | 2500                  | 1,56,52,174                | 67%         |
| 10     | NK Protin   | 5.80            | M/S N.K.PROTEINS PVT LTD.  | 2000                  | 50,50,505                  | 65%         |
| 11     | HAVMORE     | 1.50            | Havmor Ice Cream Ltd       | 3000                  | 96,15,385                  | 53%         |
| 12     | Jahan       | 0.65            | JahanSteels Ltd            | 4000                  | 1,08,33,333                | 35%         |
| 13     | TECHNOVA    | 3.59            | TECHNOVAA PLASTIC IND      | 3000                  | 79,93,730                  | 34%         |
| 14     | A M Steel   | 4.20            | M/S A M STEEL              | 3500                  | 89,38,547                  | 33%         |
| 15     | Y-tec       | 4.40            | SKH Y- TEC INDIA PVT. LTD. | 2000                  | 27,02,703                  | 15%         |
| 16     | MANGALAM    | 1.55            | M/s. Mangalam Alloys Ltd.  | 2000                  | 1,73,59,050                | 15%         |

Table 101 - Basic details of feeders in Group B - UGVCL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional  $I^2R$  method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|-------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | 11 kV Abeer | 99          | 0.983            | 1.709                           | 16,751                  |
| 2      | Kikani      | 178         | 0.947            | 0.348                           | 11,031                  |
| 3      | 11 KV ACHAL | 167         | 0.869            | 1.076                           | 30,011                  |
| 4      | Vivekanand  | 141         | 0.824            | 0.760                           | 15,102                  |
| 5      | 11 KV ANMOL | 187         | 0.737            | 0.950                           | 33,203                  |
| 6      | VENUS       | 76          | 0.687            | 4.431                           | 25,593                  |
| 7      | AMITARA     | 144         | 0.669            | 5.191                           | 1,07,632                |
| 8      | Ajay Ind    | 130         | 0.606            | 0.663                           | 11,211                  |
| 9      | Guala       | 75          | 0.493            | 2.405                           | 13,530                  |
| 10     | NK Protin   | 67          | 0.468            | 2.819                           | 12,654                  |
| 11     | HAVMORE     | 164         | 0.329            | 0.950                           | 25,538                  |
| 12     | Jahan       | 261         | 0.167            | 0.411                           | 28,028                  |
| 13     | TECHNOVA    | 170         | 0.159            | 2.269                           | 65,583                  |

| Sl No. | Feeder Name | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|-------------|-------------|------------------|---------------------------------|-------------------------|
| 14     | A M Steel   | 54          | 0.154            | 2.659                           | 7,752                   |
| 15     | Y-tec       | 111         | 0.049            | 2.785                           | 34,316                  |
| 16     | MANGALAM    | 265         | 0.049            | 0.981                           | 68,901                  |

Table 102 - Calculation of peak power losses at 11 kV for feeders in Group B - UGVCL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|-------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11 kV Abeer | 1,44,203        | 92,974                 | 2,37,177         | 0.8%               |
| 2      | Kikani      | 91,513          | 1,47,837               | 2,39,350         | 1.0%               |
| 3      | 11 KV ACHAL | 2,28,357        | 1,64,355               | 3,92,712         | 1.3%               |
| 4      | Vivekanand  | 1,09,061        | 97,495                 | 2,06,556         | 1.2%               |
| 5      | 11 KV ANMOL | 2,14,224        | 1,39,362               | 3,53,586         | 1.3%               |
| 6      | VENUS       | 1,53,998        | 64,984                 | 2,18,982         | 2.9%               |
| 7      | AMITARA     | 6,30,927        | 1,01,293               | 7,32,220         | 3.5%               |
| 8      | Ajay Ind    | 59,485          | 71,629                 | 1,31,114         | 0.9%               |
| 9      | Guala       | 58,448          | 58,316                 | 1,16,764         | 0.7%               |
| 10     | NK Protin   | 51,876          | 44,277                 | 96,152           | 1.9%               |
| 11     | HAVMORE     | 73,502          | 46,626                 | 1,20,128         | 1.2%               |
| 12     | Jahan       | 40,907          | 31,525                 | 72,433           | 0.7%               |
| 13     | TECHNOVA    | 91,420          | 22,582                 | 1,14,002         | 1.4%               |
| 14     | A M Steel   | 10,450          | 25,477                 | 35,928           | 0.4%               |
| 15     | Y-tec       | 14,718          | 4,632                  | 19,350           | 0.7%               |
| 16     | MANGALAM    | 29,289          | 4,591                  | 33,880           | 0.2%               |

Table 103 - Technical loss calculation at 11 kV level for feeders in Group B - UGVCL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|-------------|------------------------------|-------------------------------|--------------------|
| 1      | 11 kV Abeer | 23.6                         | 2,06,736                      | 0.7%               |
| 2      | Kikani      | 25.3                         | 2,21,628                      | 0.9%               |
| 3      | 11 KV ACHAL | 26.9                         | 2,35,644                      | 0.8%               |

| Sl No. | Feeder Name | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|-------------|------------------------------|-------------------------------|--------------------|
| 4      | Vivekanand  | 17.9                         | 1,56,804                      | 0.9%               |
| 5      | 11 KV ANMOL | 44.3                         | 3,88,068                      | 1.4%               |
| 6      | VENUS       | 23.9                         | 2,09,364                      | 2.7%               |
| 7      | AMITARA     | 90.2                         | 7,90,152                      | 3.8%               |
| 8      | Ajay Ind    | 11.6                         | 1,01,616                      | 0.7%               |
| 9      | Guala       | 6.8                          | 59,568                        | 0.4%               |
| 10     | NK Protin   | 12.3                         | 1,07,748                      | 2.1%               |
| 11     | HAVMORE     | 10.2                         | 89,352                        | 0.9%               |
| 12     | Jahan       | 5.3                          | 46,428                        | 0.4%               |
| 13     | TECHNOVA    | 11.5                         | 1,00,740                      | 1.3%               |
| 14     | A M Steel   | 5.3                          | 46,428                        | 0.5%               |
| 15     | Y-tec       | 0.8                          | 7,008                         | 0.3%               |
| 16     | MANGALAM    | 0.4                          | 3,504                         | 0.0%               |

Table 104 - 11 kV loss results from ETAP software for feeders in Group B – UGVCL

### Comparison of ETAP loss with energy audit

Since UGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name | ETAP Loss (kWh) | ETAP Loss (%) | EA Loss (kWh) | EA Loss (%) |
|--------|-------------|-----------------|---------------|---------------|-------------|
| 1      | 11 kV Abeer | 2,06,736        | 0.7%          | 1,63,000      | 0.6%        |
| 2      | Kikani      | 2,21,628        | 0.9%          | 56,000        | 0.2%        |
| 3      | 11 KV ACHAL | 2,35,644        | 0.8%          | 1,95,000      | 0.7%        |
| 4      | Vivekanand  | 1,56,804        | 0.9%          | 64,000        | 0.4%        |
| 5      | 11 KV ANMOL | 3,88,068        | 1.4%          | 4,37,000      | 1.6%        |
| 6      | VENUS       | 2,09,364        | 2.7%          | 2,45,000      | 3.2%        |
| 7      | AMITARA     | 7,90,152        | 3.8%          | 6,62,000      | 3.2%        |
| 8      | Ajay Ind    | 1,01,616        | 0.7%          | 74,000        | 0.5%        |
| 9      | Guala       | 59,568          | 0.4%          | 36,000        | 0.2%        |
| 10     | NK Protin   | 1,07,748        | 2.1%          | 1,00,000      | 2.0%        |
| 11     | HAVMORE     | 89,352          | 0.9%          | 5,000         | 0.1%        |
| 12     | Jahan       | 46,428          | 0.4%          | -52,000       | -0.5%       |
| 13     | TECHNOVA    | 1,00,740        | 1.3%          | 51,000        | 0.6%        |
| 14     | A M Steel   | 46,428          | 0.5%          | 16,000        | 0.2%        |
| 15     | Y-tec       | 7,008           | 0.3%          | 4,000         | 0.1%        |
| 16     | MANGALAM    | 3,504           | 0.0%          | -1,17,000     | -0.7%       |

Table 105 - Comparison of ETAP loss with energy audit

**Computation of loss at 66 kV level**

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|-------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11 kV Abeer | 1,139                 | 0.02%          | 1,752                   | 0.04%                      |
| 2      | Kikani      | 723                   | 0.01%          | 876                     | 0.02%                      |
| 3      | 11 KV ACHAL | 1,804                 | 0.02%          | 3,504                   | 0.02%                      |
| 4      | Vivekanand  | 861                   | 0.02%          | 876                     | 0.13%                      |
| 5      | 11 KV ANMOL | 1,692                 | 0.01%          | 2,628                   | 0.01%                      |
| 6      | VENUS       | 1,216                 | 0.01%          | 4,380                   | 0.01%                      |
| 7      | AMITARA     | 4,984                 | 0.01%          | 8,760                   | 0.01%                      |
| 8      | Ajay Ind    | 470                   | 0.00%          | 876                     | 0.00%                      |
| 9      | Guala       | 462                   | 0.01%          | 2,628                   | 0.00%                      |
| 10     | NK Protin   | 534                   | 0.01%          | 2,628                   | 0.01%                      |
| 11     | HAVMORE     | 581                   | 0.01%          | 876                     | 0.01%                      |
| 12     | Jahan       | 323                   | 0.00%          | -                       | 0.01%                      |
| 13     | TECHNOVA    | 722                   | 0.00%          | 876                     | 0.00%                      |
| 14     | A M Steel   | 83                    | 0.00%          | 876                     | 0.01%                      |
| 15     | Y-tec       | 116                   | 0.00%          | -                       | 0.00%                      |
| 16     | MANGALAM    | 231                   | 0.00%          | -                       | 0.00%                      |

Table 106 - Loss calculation at 66 kV level for feeders in Group B - UGVCL

**Saving due to conversion to 66 kV level**

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|-------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | 11 kV Abeer | 2,06,736                            | 1,752                   | 2.12                                | 0.04                    |
| 2      | Kikani      | 2,21,628                            | 876                     | 2.12                                | 0.05                    |
| 3      | 11 KV ACHAL | 2,35,644                            | 3,504                   | 2.12                                | 0.05                    |
| 4      | Vivekanand  | 1,56,804                            | 876                     | 2.12                                | 0.03                    |

| Sl No. | Feeder Name | 11 kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|-------------|-------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 5      | 11 KV ANMOL | 3,88,068                            | 2,628                   | 2.12                                | 0.08                    |
| 6      | VENUS       | 2,09,364                            | 4,380                   | 2.12                                | 0.04                    |
| 7      | AMITARA     | 7,90,152                            | 8,760                   | 2.12                                | 0.17                    |
| 8      | Ajay Ind    | 1,01,616                            | 876                     | 2.12                                | 0.02                    |
| 9      | Guala       | 59,568                              | 2,628                   | 2.12                                | 0.01                    |
| 10     | NK Protin   | 1,07,748                            | 2,628                   | 2.12                                | 0.02                    |
| 11     | HAVMORE     | 89,352                              | 876                     | 2.12                                | 0.02                    |
| 12     | Jahan       | 46,428                              | -                       | 2.12                                | 0.01                    |
| 13     | TECHNOVA    | 1,00,740                            | 876                     | 2.12                                | 0.02                    |
| 14     | A M Steel   | 46,428                              | 876                     | 2.12                                | 0.01                    |
| 15     | Y-tec       | 7,008                               | -                       | 2.12                                | 0.00                    |
| 16     | MANGALAM    | 3,504                               | -                       | 2.12                                | 0.00                    |

Table 107 - Annual saving due to conversion into 66 kV for feeders in Group B - UGVCL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|-------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11 kV Abeer | 840.00                               | 1.02                                | 5.49                              | 6.50                                        |
| 2      | Kikani      | 520.00                               | 1.01                                | 1.53                              | 2.54                                        |
| 3      | 11 KV ACHAL | 840.00                               | 1.02                                | 3.65                              | 4.66                                        |
| 4      | Vivekanand  | 680.00                               | 1.01                                | 2.73                              | 3.74                                        |
| 5      | 11 KV ANMOL | 840.00                               | 1.02                                | 3.28                              | 4.30                                        |
| 6      | VENUS       | 9,830.00                             | 1.19                                | 13.40                             | 14.59                                       |
| 7      | AMITARA     | 5,280.00                             | 1.10                                | 15.61                             | 16.71                                       |
| 8      | Ajay Ind    | 1,470.00                             | 1.03                                | 2.45                              | 3.48                                        |
| 9      | Guala       | 620.00                               | 1.01                                | 7.51                              | 8.52                                        |
| 10     | NK Protin   | 2,590.00                             | 1.05                                | 11.19                             | 12.24                                       |
| 11     | HAVMORE     | 5,530.00                             | 1.11                                | 3.28                              | 4.39                                        |
| 12     | Jahan       | 620.00                               | 1.01                                | 1.72                              | 2.73                                        |
| 13     | TECHNOVA    | 680.00                               | 1.01                                | 7.12                              | 8.13                                        |
| 14     | A M Steel   | 3,780.00                             | 1.07                                | 8.25                              | 9.32                                        |
| 15     | Y-tec       | 2,900.00                             | 1.06                                | 8.62                              | 9.67                                        |

| Sl No. | Feeder Name | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|-------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 16     | MANGALAM    | 840.00                               | 1.02                                | 3.37                              | 4.39                                        |

Table 108 - Conversion cost for supply at 66kV level for feeders in Group B - UGVCL

### Payback period for conversion to 66 kV level

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|-------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kV Abeer | 6.50                                        | 0.04                    | 150                    |
| 2      | Kikani      | 2.54                                        | 0.05                    | 54                     |
| 3      | 11 KV ACHAL | 4.66                                        | 0.05                    | 95                     |
| 4      | Vivekanand  | 3.74                                        | 0.03                    | 113                    |
| 5      | 11 KV ANMOL | 4.30                                        | 0.08                    | 53                     |
| 6      | VENUS       | 14.59                                       | 0.04                    | 336                    |
| 7      | AMITARA     | 16.71                                       | 0.17                    | 101                    |
| 8      | Ajay Ind    | 3.48                                        | 0.02                    | 163                    |
| 9      | Guala       | 8.52                                        | 0.01                    | 706                    |
| 10     | NK Protin   | 12.24                                       | 0.02                    | 549                    |
| 11     | HAVMORE     | 4.39                                        | 0.02                    | 234                    |
| 12     | Jahan       | 2.73                                        | 0.01                    | 277                    |
| 13     | TECHNOVA    | 8.13                                        | 0.02                    | 384                    |
| 14     | A M Steel   | 9.32                                        | 0.01                    | 965                    |
| 15     | Y-tec       | 9.67                                        | 0.00                    | 6,510                  |
| 16     | MANGALAM    | 4.39                                        | 0.00                    | 5,907                  |

Table 109 - Payback period for conversion to 66 kV for feeders in Group B - UGVCL

## Analysis of 11 kV feeders on 55 mm<sup>2</sup> ACSR Rabbit conductors – Group C

### Basic details of feeders

Basic details of existing 11 kV feeders have been obtained from DISCOM. Consumption and load factor details have been taken for the period FY 17-18.

| Sl No. | Feeder Name | Length (ckt km) | Consumer Name     | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|-------------|-----------------|-------------------|-----------------------|----------------------------|-------------|
| 1      | 11 kV Suraj | 2.27            | Suraj Inductomelt | 2700                  | 70,68,063                  | 33%         |

| Sl No. | Feeder Name    | Length (ckt km) | Consumer Name         | Contract Demand (kVA) | Consumption in FY 18 (kWh) | Load Factor |
|--------|----------------|-----------------|-----------------------|-----------------------|----------------------------|-------------|
| 2      | SIDDHI VINAYAK | 3.50            | Siddhi Vinayak Alloys | 3500                  | 38,07,615                  | 14%         |

Table 110 - Basic details of feeders in Group C - UGCVL

### Computation of loss at 11 kV level

From the basic data tabulated above, Loss load factor, resistance of line and peak power losses have been derived as per conventional  $I^2R$  method given in Equation 2 to Equation 4 of chapter 3.

| Sl No. | Feeder Name    | Load (Amps) | Loss Load Factor | Resistance of line ( $\Omega$ ) | Peak Power Loss (Watts) |
|--------|----------------|-------------|------------------|---------------------------------|-------------------------|
| 1      | 11 kV Suraj    | 142         | 0.151            | 4.913                           | 99,061                  |
| 2      | SIDDHI VINAYAK | 125         | 0.042            | 7.592                           | 1,18,617                |

Table 111 - Calculation of peak power losses at 11 kV for feeders in Group C - UGCVL

Thereafter, technical loss at 11 kV level has been worked out by calculating the line loss and transformer loss as per methodology stated in equation 5 to 7 of chapter 3.

| Sl No. | Feeder Name    | Line Loss (kWh) | Transformer Loss (kWh) | Total Loss (kWh) | Technical Loss (%) |
|--------|----------------|-----------------|------------------------|------------------|--------------------|
| 1      | 11 kV Suraj    | 1,30,797        | 19,251                 | 1,50,048         | 2.1%               |
| 2      | SIDDHI VINAYAK | 43,614          | 6,949                  | 50,563           | 1.3%               |

Table 112 - Technical loss calculation at 11 kV level for feeders in Group C - UGCVL

Feeder details with upstream substation configuration has been mapped in ETAP and the technical loss calculated by ETAP software has been tabulated below. The analysis reports of ETAP software are attached in Annexure for reference.

| Sl No. | Feeder Name    | Loss calculated by ETAP (kW) | Loss calculated by ETAP (kWh) | Technical Loss (%) |
|--------|----------------|------------------------------|-------------------------------|--------------------|
| 1      | 11 kV Suraj    | 18                           | 1,57,680                      | 2.2%               |
| 2      | SIDDHI VINAYAK | 6.3                          | 55,188                        | 1.4%               |

Table 113 - 11 kV loss results from ETAP software for feeders in Group C – UGCVL

### Comparison of ETAP loss with energy audit

Since UGVCL conducts monthly energy audit on the 11 kV feeders, it is possible to compare the results of energy audit with those from ETAP –

| Sl No. | Feeder Name    | ETAP Loss (kWh) | ETAP Loss (%) | EA Loss (kWh) | EA Loss (%) |
|--------|----------------|-----------------|---------------|---------------|-------------|
| 1      | 11 kV Suraj    | 1,57,680        | 2.2%          | 1,08,000      | 1.5%        |
| 2      | SIDDHI VINAYAK | 55,188          | 1.4%          | 57,000        | 1.5%        |

Table 114 - Comparison of ETAP loss with energy audit

### Computation of loss at 66 kV level

Now, the same feeders from previous analysis have been re-evaluated at 66 kV level in order to compute losses at 66 kV. Results from conventional and ETAP method are tabulated below –

| Sl No. | Feeder Name    | 66 kV Line Loss (kWh) | 66 kV Loss (%) | 66 kV Loss (ETAP) (kWh) | 66 kV Loss (%) as per ETAP |
|--------|----------------|-----------------------|----------------|-------------------------|----------------------------|
| 1      | 11 kV Suraj    | 302                   | 0.00%          | -                       | 0.00%                      |
| 2      | SIDDHI VINAYAK | 101                   | 0.00%          | -                       | 0.00%                      |

Table 115 - Loss calculation at 66 kV level for feeders in Group C - UGCVL

### Saving due to conversion to 66 kV level

Upon conversion to 66 kV level, it is observed that the loss level is substantially reduced at higher voltage level. Therefore, there is possibility of cost avoidance while supplying at 66 kV. The annual saving per conversion has been tabulated below taking power purchase cost of FY 17-18 -

| Sl No. | Feeder Name    | 11kV Loss calculated by ETAP (kWh) | 66 kV Loss (ETAP) (kWh) | Power purchase cost (VC) (Rs. /kWh) | Annual Saving (Rs. Cr.) |
|--------|----------------|------------------------------------|-------------------------|-------------------------------------|-------------------------|
| 1      | 11 kV Suraj    | 1,57,680                           | 0                       | 2.12                                | 0.07                    |
| 2      | SIDDHI VINAYAK | 55,188                             | 0                       | 2.12                                | 0.04                    |

Table 116 - Annual saving due to conversion into 66 kV for feeders in Group C - UGCVL

### Cost of conversion to 66 kV level

As discussed in chapter 3, there will be expenses involved in 66 kV conversion both on consumer side as well as DISCOM side. Total conversion cost has been calculated based on equations 13 to 17 of chapter 3. Results of calculation of conversion cost have been tabulated below -

| Sl No. | Feeder Name    | Applicable circle rate (Rs./ sq mtr) | Expenses on consumer side (Rs. Cr.) | Expenses on DISCOM side (Rs. Cr.) | Total Cost of conversion to 66 kV (Rs. Cr.) |
|--------|----------------|--------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 1      | 11 kV Suraj    | 620                                  | 1.01                                | 4.69                              | 5.70                                        |
| 2      | SIDDHI VINAYAK | 1470                                 | 1.03                                | 6.96                              | 7.99                                        |

Table 117 - Conversion cost for supply at 66kV level for feeders in Group C - UGCVL

### **Payback period for conversion to 66 kV level**

As given in equation 18 of chapter 3, the saving accrued each year has been divided by total conversion cost to determine the payback period. As calculated in the table below, payback period is in very high range making it unviable for higher voltage conversion.

| Sl No. | Feeder Name    | Total Cost of conversion to 66 kV (Rs. Cr.) | Annual Saving (Rs. Cr.) | Payback period (Years) |
|--------|----------------|---------------------------------------------|-------------------------|------------------------|
| 1      | 11 kV Suraj    | 5.70                                        | 0.03                    | 171                    |
| 2      | SIDDHI VINAYAK | 7.99                                        | 0.01                    | 683                    |

Table 118 - Payback period for conversion to 66 kV for feeders in Group C – UGCVL

## CHAPTER: 8 CONCLUSION FROM LOSS STUDY

As per findings of the study conducted, although conversion of voltage level to 66 kV shall result in reduced loss levels, however the cost of 66 kV conversion is too high to recover within reasonable payback period. As discussed in Chapter – 3, due to RoW issues in laying overhead lines on H-frame for the proposed conversion, XLPE cable shall have to be laid. As 66 kV XLPE (630 mm<sup>2</sup>) costs Rs. 1.84 Cr., in comparison, single circuit overhead line on H-frame with Dog conductor costs only Rs. 0.15 Cr. Hence, major component in cost of conversion can be attributed to 66 kV XLPE cable cost. DISCOM-wise summary of findings is given in subsequent sections.

### Reduction in technical loss by conversion to 66 kV

Summary of technical loss reduction in sample feeders is tabulated below for reference –

| DISCOM             | Total Loss at 11 kV (kWh) | Percentage loss at 11 kV | Total Loss at 66 kV (kWh) | Percentage loss at 66 kV |
|--------------------|---------------------------|--------------------------|---------------------------|--------------------------|
| DGVCL              | 57,41,304                 | 1.20%                    | 63,948                    | 0.01%                    |
| MGVCL              | 1,04,75,208               | 1.82%                    | 1,05,120                  | 0.02%                    |
| PGVCL              | 2,26,94,532               | 3.02%                    | 1,19,136                  | 0.02%                    |
| UGVCL              | 93,95,976                 | 1.74%                    | 69,204                    | 0.01%                    |
| <b>All DISCOMs</b> | <b>4,83,07,020</b>        | <b>2.06%</b>             | <b>3,57,408</b>           | <b>0.02%</b>             |

Table 119 - Summary of DISCOM-wise technical loss levels on sample consumers

As given in table above, combined loss of sample 11 kV feeders from all DISCOMs is 2.06 % which amounts to about 48.3 MU. This loss pertains to sample **express feeders** which were considered for the study.

It may be recalled as per Table 1 of this document, there are total 683 nos. of 11 kV consumers within 2.5 MVA and 4 MVA which were part of the study and from which 152 nos. of samples were taken in the study. Extrapolating the results of sample consumers from each DISCOM, we can generalize the technical loss at 11 kV for each DISCOM as follows -

| DISCOM       | Number of Consumers | Contract Demand (kVA) | Units Consumed (MWh) | Percentage Loss at 11 kV | Units Lost (MWh) |
|--------------|---------------------|-----------------------|----------------------|--------------------------|------------------|
| DGVCL        | 105                 | 66,100                | 1,274,485            | 1.20%                    | 15,294           |
| MGVCL        | 90                  | 117,590               | 1,039,719            | 1.82%                    | 18,923           |
| PGVCL        | 314                 | 148,300               | 3,077,093            | 3.02%                    | 92,928           |
| UGVCL        | 174                 | 128,600               | 1,953,920            | 1.74%                    | 33,998           |
| <b>Total</b> | <b>683</b>          | <b>460,590</b>        | <b>7,345,218</b>     | <b>-</b>                 | <b>161,143</b>   |

Table 120 - Summary of DISCOM-wise technical loss levels on all consumers under study

Therefore, units lost per kVA of contract demand =  $161,143 / 460,590 = 0.35$  kWh

## Total Cost of conversion to 66 kV

DISCOM-wise cost of conversion for sample feeders are as follows –

| DISCOM             | No. of samples | Conversion cost for DISCOMs (Rs. Cr.) | Conversion cost for Consumers (Rs. Cr.) | Total Conversion cost (Rs. Cr.) |
|--------------------|----------------|---------------------------------------|-----------------------------------------|---------------------------------|
| DGVCL              | 21             | 97.99                                 | 21.98                                   | 119.98                          |
| MGVCL              | 41             | 277.90                                | 42.24                                   | 320.14                          |
| PGVCL              | 50             | 344.74                                | 51.20                                   | 395.94                          |
| UGVCL              | 41             | 224.75                                | 42.79                                   | 267.54                          |
| <b>All DISCOMs</b> | <b>153</b>     | <b>945.39</b>                         | <b>158.22</b>                           | <b>1,103.60</b>                 |

Table 121 - Summary of conversion cost of sample feeders

**Conversion cost per kVA = 1103.60 / 460,590 = INR. 23,960 per kVA**

Now, the cost can be extrapolated to cover all relevant consumers as follows –

| DISCOM             | No. of consumers under study | Conversion cost for DISCOMs (Rs. Cr.) | Conversion cost for Consumers (Rs. Cr.) | Total Conversion cost (Rs. Cr.) |
|--------------------|------------------------------|---------------------------------------|-----------------------------------------|---------------------------------|
|                    | 1                            | 2                                     | 3                                       | 4 = 2 + 3                       |
| DGVCL              | 105                          | 489.97                                | 109.92                                  | 599.90                          |
| MGVCL              | 90                           | 610.03                                | 92.72                                   | 702.75                          |
| PGVCL              | 314                          | 2,164.99                              | 321.54                                  | 2,486.53                        |
| UGVCL              | 174                          | 953.80                                | 181.61                                  | 1,135.40                        |
| <b>All DISCOMs</b> | <b>683</b>                   | <b>4,220.25</b>                       | <b>706.29</b>                           | <b>4,926.54</b>                 |

Table 122 - Summary of conversion cost for feeders under study

## Cost avoidance by conversion into 66 kV

Due to difference in percentage loss on 66 kV vis-à-vis 11 kV, there is significant cost avoidance. This can be calculated as follows –

| DISCOM             | Percentage loss at 11 kV | Percentage loss at 66 kV | Saving in Percentage |
|--------------------|--------------------------|--------------------------|----------------------|
|                    | 1                        | 2                        | 3 = 1-2              |
| DGVCL              | 1.20%                    | 0.02 %                   | 1.18%                |
| MGVCL              | 1.82%                    | 0.02 %                   | 1.80%                |
| PGVCL              | 3.02%                    | 0.02 %                   | 3.00%                |
| UGVCL              | 1.74%                    | 0.01 %                   | 1.73%                |
| <b>All DISCOMs</b> | <b>2.06%</b>             | <b>0.02 %</b>            | <b>2.04 %</b>        |

Table 123 - Saving in percentage loss DISCOM-wise

Now, the same percentage can be applied to all 683 consumers to find out potential unit saving. Then the resultant can be multiplied by applicable power purchase variable cost of INR 2.12 to get saving in monetary terms.

| DISCOM       | No. of consumer under study | Contract Demand (kVA) | Difference in Percentage loss | Units Consumed (MWh) | Units saving potential (MU) | Saving in INR. Cr. |
|--------------|-----------------------------|-----------------------|-------------------------------|----------------------|-----------------------------|--------------------|
|              | 1                           | 2                     | 3                             | 4                    | 5 = 3 x 4                   | 6 = 5 x 2.12       |
| DGVCL        | 105                         | 289,850               | 1.18%                         | 1,274,485            | 15.04                       | 3.19               |
| MGVCL        | 90                          | 259,790               | 1.80%                         | 1,039,719            | 18.71                       | 3.97               |
| PGVCL        | 314                         | 880,700               | 3.00%                         | 3,077,093            | 92.31                       | 19.57              |
| UGVCL        | 174                         | 522,350               | 1.73%                         | 1,953,920            | 33.80                       | 7.17               |
| <b>Total</b> | <b>683</b>                  | <b>1,952,690</b>      | <b>2.04 %</b>                 | <b>7,345,218</b>     | <b>149.84</b>               | <b>31.77</b>       |

Table 124 - Saving potential for conversion into 66 kV

Therefore per kVA saving from conversion to 66 kV =  $31.77 / 1,952,690 = \text{INR. } 162.70$

Thus the following cost and saving can be determined for standard industrial loads –

| Contract Demand (kVA) | Per kVA cost of conversion (INR.) | Per kVA saving potential (INR.) | Conversion cost (INR. Cr.) | Saving (INR. Cr.)  |
|-----------------------|-----------------------------------|---------------------------------|----------------------------|--------------------|
| 1                     | 2                                 | 3                               | 4 = 1 x 2 (in Cr.)         | 5 = 1 x 3 (in Cr.) |
| 200                   | 23,960                            | 162.70                          | 0.48                       | 0.003              |
| 500                   | 23,960                            | 162.70                          | 1.20                       | 0.01               |
| 1,000                 | 23,960                            | 162.70                          | 2.40                       | 0.02               |
| 1,500                 | 23,960                            | 162.70                          | 3.59                       | 0.02               |
| 2,000                 | 23,960                            | 162.70                          | 4.79                       | 0.03               |

Table 125 - Cost and saving for standard industrial loads

## Cost benefit

### Simple payback calculation

Payback period calculation (DISCOM share of investment) for the entire conversion is given as follows –

| DISCOM | Conversion cost for DISCOMs (Rs. Cr.) | Saving in Rs. Cr. | Payback period (Years) |
|--------|---------------------------------------|-------------------|------------------------|
|        | 1                                     | 2                 | 3 = 1/2                |
| DGVCL  | 599.90                                | 3.19              | 188                    |
| MGVCL  | 702.75                                | 3.97              | 177                    |

| DISCOM             | Conversion cost for DISCOMs (Rs. Cr.) | Saving in Rs. Cr. | Payback period (Years) |
|--------------------|---------------------------------------|-------------------|------------------------|
| PGVCL              | 2,486.53                              | 19.57             | 127                    |
| UGVCL              | 1,135.40                              | 7.17              | 158                    |
| <b>All DISCOMs</b> | <b>4,926.54</b>                       | <b>31.77</b>      | <b>155</b>             |

Table 126 - Payback calculation for all relevant feeders

On an average, simple payback period is 155 years which makes the project unviable for investment.

### Discounted payback calculation

As the variable cost of power shall increase every year, the savings from project will also increase at same rate. It is assumed that variable cost of power shall increase at a rate of 8% each year. Also, to calculate NPV of cash flow, an 8.55 % discounting rate has been assumed<sup>8</sup>.

| Year | Cash Flow (INR Cr.)      | Discounted Cash Flow (INR Cr.) | Cumulative Discounted Cash Flow (INR Cr.) |
|------|--------------------------|--------------------------------|-------------------------------------------|
| 0    | 4,926.54                 | 4,926.54                       | -4,926.54                                 |
| 1    | 31.77                    | 29.27                          | -4,897.27                                 |
| 2    | 34.31                    | 29.12                          | -4,868.15                                 |
| 3    | 37.06                    | 28.97                          | -4,839.18                                 |
| 4    | 40.02                    | 28.82                          | -4,810.36                                 |
| 5    | 43.22                    | 28.68                          | -4,781.68                                 |
| ...  | ...                      | ...                            | ...                                       |
| 375  | 10,05,77,71,55,04,234.00 | 4.38                           | -9.94                                     |
| 376  | 10,86,23,93,27,44,573.00 | 4.36                           | -5.58                                     |
| 377  | 11,73,13,84,73,64,139.00 | 4.33                           | -1.25                                     |
| 378  | 12,66,98,95,51,53,270.00 | 4.31                           | 3.07                                      |
| 379  | 13,68,34,87,15,65,532.00 | 4.29                           | 7.36                                      |
| 380  | 14,77,81,66,12,90,774.00 | 4.27                           | 11.62                                     |

Table 127 - Truncated table for discount payback calculation

Discounted Payback period =  $377 + 1.25/4/31 = 377.29$  years (highlighted in table above)

<sup>8</sup> based on State Bank Base Rate of Dec 2018

## CHAPTER: 9 CALCULATION OF COST OF SUPPLY

In the earlier chapter, overall loss of 11 kV express feeders was calculated as 2.06%. In this chapter, the cost of supply for **express feeders** have been calculated. Since only express feeders shall be technically possible to upgrade to higher voltage, thus the difference in cost of supply between 11 kV express feeders and 66 kV express feeders has been calculated for reference. In order to calculate the cost of supply at 66 kV and 11 kV voltage levels, overall cost is allocated to each voltage level on the basis of power purchase cost and network cost. As power purchase cost comprises fixed and variable costs, these have been separately treated in order to find the total allocation on account of power purchase.

Network costs have been derived based on inputs from relevant tariff orders. Details of the same is depicted in following sections.

### Allocation of power purchase cost

Power purchase cost of Gujarat has been derived from Table 7.1 (Base price of power purchase) in tariff order for FY 2018-19 as follows:

| Cost component                                           | Amount (INR Cr.) |
|----------------------------------------------------------|------------------|
| Fixed Cost (including GETCO, GUVNL, PGCIL, SLDC charges) | 19,315           |
| Variable Cost                                            | 19,532           |
| Total power purchase cost                                | 38,847           |
| Energy requirement (MU)                                  | 91,973           |
| <b>Fixed Cost per unit (INR / kWh)</b>                   | <b>2.10</b>      |
| <b>Variable + Other Cost per unit (INR / kWh)</b>        | <b>2.12</b>      |
| <b>Per unit cost (INR / kWh)</b>                         | <b>4.22</b>      |

Table 128 - Power purchase cost break-up for Gujarat

Power sold by DISCOMs at HT (11kV) and LT level has been derived from Table 5.2 (Approved Sales and Revenue from existing tariff for FY 2018-19) in respective tariff orders for FY 2018-19 as follows:

| Sales at Voltage Level  | DGVCL  | MGVCL | PGVCL  | UGVCL  | Total         |
|-------------------------|--------|-------|--------|--------|---------------|
| <b>LT level (MU)</b>    | 10,586 | 6,366 | 16,744 | 15,035 | <b>48,731</b> |
| <b>11 kV level (MU)</b> | 8,245  | 3,534 | 8,248  | 4,802  | <b>24,829</b> |
| <b>11 kV + LT (MU)</b>  | 18,831 | 9,900 | 24,992 | 19,873 | <b>73,576</b> |

Table 129 - Voltage level-wise energy sold by DISCOMs

Since the quantum of power sold at 11 kV and LT level combined is 73,576 MU, it can be deduced that energy sold at 66 kV level shall be  $91,973 - 73,576 = 18,377$  MU.

Now the variable charges can be allocated based on voltage-wise losses. It is noted that the actual transmission losses of GETCO are 3.85% as given in GETCO True-up order for FY 2016-17 and tariff order for FY 2018-19 (Issue 29: Transmission loss). Therefore, the transmission losses till the point of delivery of 66 kV network is 3.85%.

Further, loss on 11 kV **express feeders** has been determined in Chapter 4, 5, 6, 7 and 8 as follows:

| DISCOM             | Percentage loss at 11 kV |
|--------------------|--------------------------|
| DGVCL              | 1.20%                    |
| MGVCL              | 1.82%                    |
| PGVCL              | 3.02%                    |
| UGVCL              | 1.74%                    |
| <b>All DISCOMs</b> | <b>2.06%</b>             |

Table 130 - Percentage loss on 11 kV express feeders

Therefore, losses till the point of delivery of 11 kV network = 3.85 + 2.06 = 5.91 %.

Now, we can assign variable cost of INR. 19,532 Cr. based on voltage-wise losses as follows -

| Voltage Level | Energy Sale (MU) | Loss (%) | Loss (MU)       | Energy Sale + Loss (MU) |
|---------------|------------------|----------|-----------------|-------------------------|
| 1             | 2                | 3        | 4 = 2 x 3 / 100 | 5 = 2 + 4               |
| <b>11 kV</b>  | 24,829           | 5.91     | 1,467           | 26,296                  |
| <b>66 kV</b>  | 18,377           | 3.85     | 707             | 19,084                  |

Table 131 - Voltage-wise T&D loss and energy sales

| Voltage Level | Energy Sale (MU) | Energy Sale + T&D Loss (MU) | Per unit Variable Cost (INR) | Proportionate Variable Cost (INR Cr.) | Allocated Variable Cost (INR /kWh) |
|---------------|------------------|-----------------------------|------------------------------|---------------------------------------|------------------------------------|
| 1             | 2                | 3                           | 4                            | 5                                     | 6 = 5 / 2                          |
| <b>11 kV</b>  | 24,829           | 26,296                      | 2.12                         | 5,575                                 | 2.24                               |
| <b>66 kV</b>  | 18,377           | 19,084                      | 2.12                         | 4,046                                 | 2.20                               |

Table 132 - Allocation of variable cost

Fixed cost of INR. 2.10 per unit can be allocated as follows:

| Voltage Level | Fixed Cost (INR / kWh) | Allocated Variable Cost (INR / kWh) | Cost of Supply per unit sold (Rs. / unit) |
|---------------|------------------------|-------------------------------------|-------------------------------------------|
| 1             | 2                      | 3                                   | 4 = 2 x 3                                 |
| <b>11 kV</b>  | 2.10                   | 2.24                                | 4.34                                      |
| <b>66 kV</b>  | 2.10                   | 2.20                                | 4.30                                      |

Table 133 - Allocation of power purchase cost

## Allocation of Network related costs

### Allocation of 66 kV Network cost

Since GETCO cost is already included within the allocated fixed cost, therefore, additional allocation for network cost is not required for 66 kV level.

### Allocation of 11 kV Network cost

Distribution cost at 11 kV for the four DISCOMs has been calculated in DISCOM tariff orders for FY 18-19 (Table 8.3: Wheeling charges for FY 2018-19).

| Particulars                                     | Amount INR. Cr. |
|-------------------------------------------------|-----------------|
| Distribution cost of all four DISCOMs           | 4,156           |
| Distribution cost at 11 kV level (30% of total) | 1,247           |

Table 134 - Distribution cost at 11 kV level

Now, energy input at 11 kV is 85,361 MU, therefore, network cost at 11 kV can be calculated as  $1,247 \times 10 / 85,361 = \text{INR } 0.15$  per kWh.

## Voltage-wise Cost of supply

| Voltage level | Cost of power purchase (INR / unit) | Network cost (INR / unit) | Cost of supply (INR / unit) |
|---------------|-------------------------------------|---------------------------|-----------------------------|
| 11 kV         | 4.34                                | 0.15                      | 4.49                        |
| 66 kV         | 4.30                                |                           | 4.30                        |

Table 135 - Derived cost of supply at 66 kV and 11 kV

Thus, the differential of the above cost of supply, ie,  $\text{INR } 4.49 - 4.30 = \text{INR } 0.19/-$  may be appropriately passed on to consumers opting for 66 kV supply instead of 11 kV supply. The appropriate proportion of benefit to be passed on may be decided by hon'ble GERC.

## CHAPTER: 10 HT TARIFF OF OTHER STATES

As per the requirements of study, HT tariff of other states has been detailed in this chapter. No other state has been found to derive rebate to higher voltage supply by scientific method. However, the individual tariff schedules for HT consumers are given below for reference-

### Madhya Pradesh

| Voltage Level                     | Monthly Fixed Charge (INR./kVA per month) | Energy Charge up to 50% LF (INR / unit) | Energy Charge for more than 50% LF INR/ unit) |
|-----------------------------------|-------------------------------------------|-----------------------------------------|-----------------------------------------------|
| <b>Industrial Supply</b>          |                                           |                                         |                                               |
| 11 kV Supply                      | 330                                       | 6.60                                    | 6.00                                          |
| 33 kV Supply                      | 510                                       | 6.50                                    | 5.50                                          |
| 132 kV Supply                     | 610                                       | 6.05                                    | 5.25                                          |
| 220 / 400 kV Supply               | 620                                       | 5.65                                    | 5.00                                          |
| <b>Non -Industrial Supply</b>     |                                           |                                         |                                               |
| 11 kV Supply                      | 300                                       | 6.80                                    | 6.30                                          |
| 33 kV Supply                      | 430                                       | 6.70                                    | 6.10                                          |
| 132 kV Supply                     | 540                                       | 6.20                                    | 5.50                                          |
| <b>Shopping Malls</b>             |                                           |                                         |                                               |
| 11 kV Supply                      | 270                                       | 6.80                                    | 6.25                                          |
| 33 kV Supply                      | 375                                       | 6.60                                    | 5.90                                          |
| 132 kV Supply                     | 510                                       | 6.00                                    | 5.40                                          |
| <b>Power intensive industries</b> |                                           |                                         |                                               |
| 11 kV Supply                      | 530                                       | 5.00                                    | 5.00                                          |
| 33 kV Supply                      | 640                                       | 4.80                                    | 4.80                                          |
| 132 kV Supply                     | 660                                       | 4.50                                    | 4.50                                          |

Table 136 - Voltage level-wise supply tariff for MP

There is 20% rebate on above owing to ToD during 2200 hrs to 600 hrs.

| Category      | Average billing rate (ABR INR / kWh) |
|---------------|--------------------------------------|
| HT Industrial | 7.06                                 |

| Category                   | Average billing rate<br>(ABR INR / kWh) |
|----------------------------|-----------------------------------------|
| HT Non – Industrial        | 8.00                                    |
| Shopping Malls             | 7.77                                    |
| Power intensive industries | 5.90                                    |

Table 137 - ABR for HT category of consumers, MP

## Rajasthan

Standard prescribed voltages by RERC –

| Contract Demand | Prescribed supply voltage |
|-----------------|---------------------------|
| Upto 1.5 MVA    | 11 kV                     |
| 1.5 to 5 MVA    | 33 kV                     |
| Above 5 MVA     | 132 or 220 kV             |

Table 138 - Standard prescribed voltages by RERC<sup>9</sup>

Rajasthan DISCOMs have a fixed base rates for HT supply. While the fixed charges per kVA per month is Rs. 185, energy consumption is charged at Rs. 7.30 per unit for 11 kV supply.

For higher voltages than 11 kV, the rebates provided are as follows –

| Supply Voltage | Prescribed rebate |
|----------------|-------------------|
| 33 kV          | 3 %               |
| 132 kV         | 4%                |
| 220 kV         | 5%                |

Table 139 - Rebates on higher supply voltages by RERC

<sup>9</sup> RERC tariff order dated 28<sup>th</sup> May 2018

| Particulars                                    | JVVNL | AVVNL | JdVVNL | Overall |
|------------------------------------------------|-------|-------|--------|---------|
| Revenue from small industrial sales (INR Cr.)  | 236   | 223   | 190    | 650     |
| Revenue from medium industrial sales (INR Cr.) | 662   | 727   | 595    | 1,984   |
| Revenue from large industrial sales (INR Cr.)  | 4,645 | 3,026 | 1,311  | 8,982   |
| Energy sold - small industrial (MU)            | 306   | 289   | 250    | 845     |
| Energy sold - medium industrial (MU)           | 792   | 895   | 736    | 2,424   |
| Energy sold - large industrial (MU)            | 5,616 | 3,484 | 1,523  | 10,662  |
| ARR - small industrial (INR / kWh)             | 7.71  | 7.72  | 7.60   | 7.69    |
| ARR - medium industrial (INR / kWh)            | 8.36  | 8.12  | 8.08   | 8.18    |
| ARR - large industrial (INR / kWh)             | 8.27  | 8.69  | 8.61   | 8.42    |

Table 140 - Calculation of realized revenue from industrial consumers - Rajasthan DISCOMs

## Maharashtra

Maharashtra DISCOM has same tariff rates for all HT supply voltages. These are given in the table below-

| Industry type               | Fixed charges (INR / kVA) | Energy charges (INR / kWh) | Wheeling charges (INR / kWh) | Total variable charges (INR / kWh) | Average Billing rate (ABR) |
|-----------------------------|---------------------------|----------------------------|------------------------------|------------------------------------|----------------------------|
| <b>HV – 66 kV and above</b> |                           |                            |                              |                                    |                            |
| HT industry (General)       | 270                       | 6.98                       | -                            | 6.98                               | 8.12                       |
| HT industry (Seasonal)      | 270                       | 7.37                       | -                            | 7.37                               | 11.56                      |
| HT Commercial               | 270                       | 11.45                      | -                            | 11.45                              | 13.13                      |
| <b>HV – 33 kV</b>           |                           |                            |                              |                                    |                            |
| HT industry (General)       | 270                       | 6.98                       | 0.09                         | 7.07                               | 8.21                       |
| HT industry (Seasonal)      | 270                       | 7.37                       | 0.09                         | 7.46                               | 11.65                      |
| HT Commercial               | 270                       | 11.45                      | 0.09                         | 11.54                              | 12.64                      |
| <b>HV – 22 &amp; 11 kV</b>  |                           |                            |                              |                                    |                            |
| HT industry (General)       | 270                       | 6.98                       | 0.82                         | 7.80                               | 8.94                       |
| HT industry (Seasonal)      | 270                       | 7.37                       | 0.82                         | 8.19                               | 12.38                      |
| HT Commercial               | 270                       | 11.45                      | 0.82                         | 12.27                              | 13.37                      |

Table 141 - HT tariff of MSEDCL

## Delhi

Industrial tariff is fixed at Rs. 250 per kVA per month as fixed charges and Rs. 7.25 per kWh as energy charges. Industrial consumers availing supply on 11 kV, 33 kV/66 kV and 220 kV are entitled for rebate of 3%, 4% and 5% respectively on the applicable energy charges.<sup>10</sup>

| DISCOM           | ABR for Industrial category<br>(INR / kWh) |
|------------------|--------------------------------------------|
| BSES Yamuna      | 9.43                                       |
| BSES Yamuna      | 9.34                                       |
| Tata Power Delhi | 9.54                                       |

Table 142 - Delhi DISCOM-wise ABR for Industrial category

## West Bengal

WBSEDCL provides load factor rebate for industrial consumers at HT supply as per the following table<sup>11</sup>-

| Load Factor range | Voltage below 33 kV (paisa / kWh) | At 33 kV supply (paisa / kWh) | Above 33 kV (paisa / kWh) |
|-------------------|-----------------------------------|-------------------------------|---------------------------|
| 55% - 60%         | 1                                 | 2                             | 3                         |
| 60% - 65%         | 7                                 | 8                             | 9                         |
| 65% - 70%         | 14                                | 29                            | 39                        |
| 70% - 75%         | 20                                | 35                            | 45                        |
| 75% - 80%         | 25                                | 40                            | 50                        |
| 80% - 85%         | 30                                | 45                            | 55                        |
| 85% - 90%         | 35                                | 50                            | 65                        |
| 90% - 92%         | 40                                | 55                            | 65                        |
| 92% - 95%         | 45                                | 60                            | 70                        |
| Above 95%         | 50                                | 65                            | 75                        |

Table 143 - LF rebate by WBSEDCL

The above load factor rebate is applicable on total quantum of energy consumed during the billing period. (For example a 33 kV industrial consumer at 85% load factor is eligible for a rebate @ 45 paise / kWh on the total quantum of energy consumed in the billing period).

<sup>10</sup> DERC tariff order for BYPL for FY 2018-19

<sup>11</sup> Tariff order of WBSEDCL for the year 2017 – 2018

Industrial consumers whose contract demand is 1.5 MVA or above get additional rebate as per following table subject to the condition that payment is made within the due date –

| Load Factor | Rebate (Paise / kWh) |
|-------------|----------------------|
| 65% to 80%  | 20                   |
| Above 80%   | 35                   |

Table 144 - Additional Load factor rebate provided by WBSEDCL

Per unit rates for industrial consumers are as follows –

| Voltage Level | Demand Charges (Rs. / kVA) | Energy Charges – Summer (Rs. / kWh) | Energy Charges – Monsoon (Rs. / kWh) | Energy Charges – Winter (Rs. / kWh) |
|---------------|----------------------------|-------------------------------------|--------------------------------------|-------------------------------------|
| 11 kV         | 384                        | 720                                 | 719                                  | 718                                 |
| 33 kV         | 384                        | 717                                 | 715                                  | 713                                 |
| 132 kV        | 384                        | 713                                 | 711                                  | 709                                 |

Table 145 - Industrial tariff rates for WBSEDCL

## CHAPTER: 11 VALIDATION OF 66 kV LOSS

### Sample 66 kV Feeders

4 Nos. of 66 kV feeders have been selected as representative sample. These feeders have been selected on the basis of average and good load factor and with underground 300 mm<sup>2</sup> XLPE cable:

| Sl. No. | Feeder Name        | Consumer Name       | Line Length (km) | LF  | Contract Demand (MVA) | Consumption in FY 18 (kWh) |
|---------|--------------------|---------------------|------------------|-----|-----------------------|----------------------------|
| 1       | 66 kV Fag Bearings | Fag Bearings India  | 3.10             | 80% | 5.32                  | 3,35,14,560                |
| 2       | 66 kV Siemens      | Siemens India Ltd   | 2.15             | 75% | 11.50                 | 31,36,375                  |
| 3       | 66 kV Toto         | Toto India Industry | 1.00             | 49% | 2.00                  | 76,83,000                  |
| 4       | 66 kV Polycab      | Polycab Wires       | 0.73             | 36% | 7.50                  | 2,13,13,800                |

Table 146 - Selected sample of 66 kV feeders for validation

#### Loss on 66 kV Fag Bearings feeder

| <u>Branch Losses Summary Report</u> |                  |       |                  |        |        |      |               |       |                   |
|-------------------------------------|------------------|-------|------------------|--------|--------|------|---------------|-------|-------------------|
| CKT / Branch                        | From-To Bus Flow |       | To-From Bus Flow |        | Losses |      | % Bus Voltage |       | Vd % Drop in Vmag |
| ID                                  | MW               | Mvar  | MW               | Mvar   | kW     | kvar | From          | To    |                   |
| Cable1                              | 4.002            | 1.442 | -4.001           | -1.441 | 1.6    | 1.1  | 100.0         | 100.0 | 0.04              |
|                                     |                  |       |                  |        | 1.6    | 1.1  |               |       |                   |

Loss in kWh =  $1.6 \times 24 \times 365 = 14,016$  units

Units consumed by Fag Bearings feeder = 3,35,14,560 units

Therefore, Loss % = 0.04 %

#### Loss on 66 kV Siemens feeder

| <u>Branch Losses Summary Report</u> |                  |       |                  |        |        |      |               |      |                   |
|-------------------------------------|------------------|-------|------------------|--------|--------|------|---------------|------|-------------------|
| CKT / Branch                        | From-To Bus Flow |       | To-From Bus Flow |        | Losses |      | % Bus Voltage |      | Vd % Drop in Vmag |
| ID                                  | MW               | Mvar  | MW               | Mvar   | kW     | kvar | From          | To   |                   |
| Cable1                              | 8.188            | 2.693 | -8.184           | -2.690 | 4.5    | 3.2  | 100.0         | 99.9 | 0.06              |
|                                     |                  |       |                  |        | 4.5    | 3.2  |               |      |                   |

Loss in kWh =  $4.5 \times 24 \times 365 = 39,420$  units

Units consumed by Siemens feeder = 31,36,375 units

Therefore, Loss % = 1.25 %

### Loss on 66 kV Toto feeder

| <u>Branch Losses Summary Report</u> |                  |       |                  |        |        |      |               |       |                         |
|-------------------------------------|------------------|-------|------------------|--------|--------|------|---------------|-------|-------------------------|
| CKT / Branch                        | From-To Bus Flow |       | To-From Bus Flow |        | Losses |      | % Bus Voltage |       | Vd<br>% Drop<br>in Vmag |
| ID                                  | MW               | Mvar  | MW               | Mvar   | kW     | kvar | From          | To    |                         |
| Cable1                              | 5.352            | 1.760 | -5.351           | -1.759 | 0.9    | 0.6  | 100.0         | 100.0 | 0.02                    |
|                                     |                  |       |                  |        | 0.9    | 0.6  |               |       |                         |

Loss in kWh =  $0.9 \times 24 \times 365 = 7,884$  units

Units consumed by Toto feeder = 76,83,000 units

Therefore, Loss % = 0.10 %

### Loss on 66 kV Polycab feeder

| <u>Branch Losses Summary Report</u> |                  |       |                  |        |        |      |               |       |                         |
|-------------------------------------|------------------|-------|------------------|--------|--------|------|---------------|-------|-------------------------|
| CKT / Branch                        | From-To Bus Flow |       | To-From Bus Flow |        | Losses |      | % Bus Voltage |       | Vd<br>% Drop<br>in Vmag |
| ID                                  | MW               | Mvar  | MW               | Mvar   | kW     | kvar | From          | To    |                         |
| Cable1                              | 2.565            | 0.843 | -2.565           | -0.843 | 0.2    | 0.1  | 100.0         | 100.0 | 0.01                    |
|                                     |                  |       |                  |        | 0.2    | 0.1  |               |       |                         |

Loss in kWh =  $0.2 \times 24 \times 365 = 1,752$  units

Units consumed by Polycab feeder = 2,13,13,800 units

Therefore, Loss % = 0.01 %

### Conclusion

Since these losses are consistent with 66 kV loss projected in Chapter -4 to 8, therefore, the loss on 66 kV feeders have been validated and found consistent with the earlier findings.

## CHAPTER: 12 TECHNICAL IMPACT OF CONVERSION

### Sample 66 / 11 kV substations

For evaluating the impact of 66 kV conversion, sample substations of all 4 DISCOMs were visited. All 66 / 11 kV substations of GETCO substations are commissioned in a uniform pattern or configuration. Therefore, the substations at Atladara and Icchapore have been taken as representative samples for technical impact study.

In this study, the consultant has mapped representative samples of Atladara and Icchapore 66 / 11 kV substations and then built scenarios to compare the impact of 66 kV conversion on voltage regulation, transformer loading etc. The consultant has also built specific scenarios to simulate outage on proposed 66 kV and remaining 11 kV feeders in order to evaluate its impact on voltage regulation, transformer loading etc.

Process followed to carry out the technical impact study is as follows-

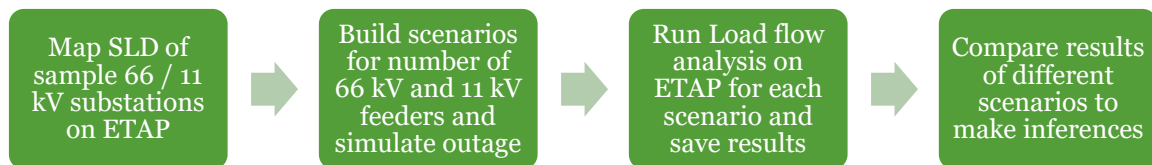


Figure 8 - Process flow for technical impact study

### Impact at Atladara 66 / 11 kV substation

Firstly the current configuration of Atladara 66 / 11 kV substation has been mapped as a Single Line Diagram on ETAP as follows-

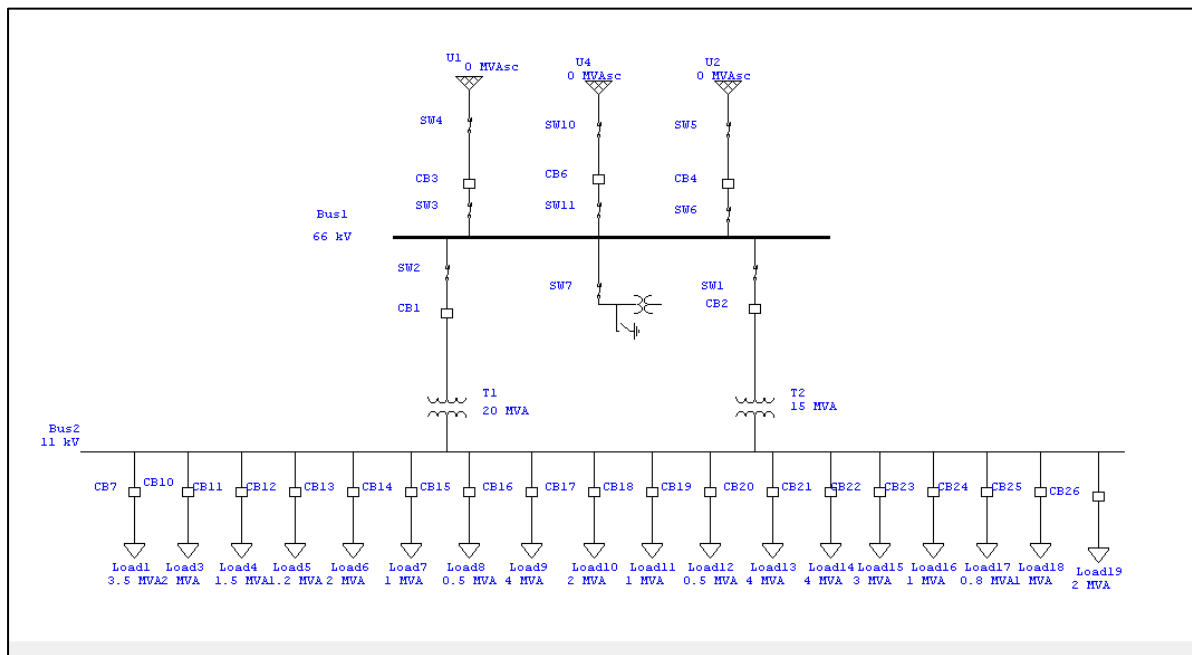


Figure 9 - SLD of Atladara 66 / 11 kV substation

Now, load flow analysis can be conducted on the substation to see the present as-is condition.

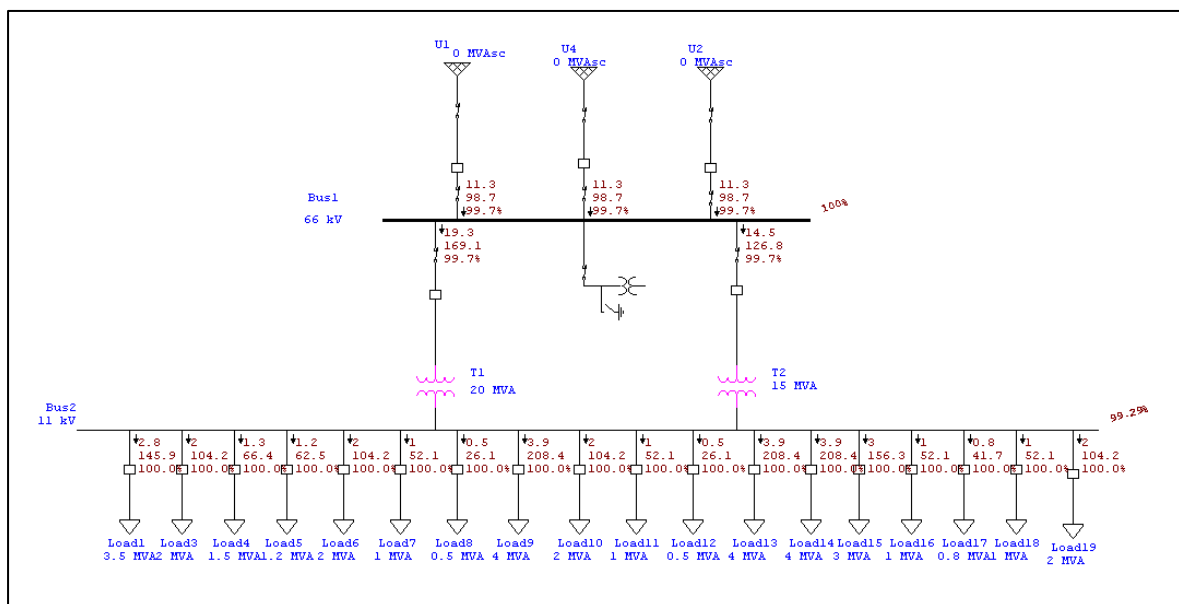


Figure 10 - Load flow analysis on As-Is condition at Atladara S/s

### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |        | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|--------|-------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp    | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 33.731     | 2.612 | 0      | 0     | Bus2      | 19.275  | 1.493 | 169.1  | 99.7  |      |
|        |        |         |      |            |       |        |       | Bus2      | 14.456  | 1.120 | 126.8  | 99.7  |      |
| Bus2   | 11.000 | 99.286  | -4.4 | 0          | 0     | 33.590 | 0.000 | Bus1      | -19.194 | 0.000 | 1014.7 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -14.396 | 0.000 | 761.0  | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |    |            |        |            |    |         |    | Total Bus Load |        |       |                 |
|------|--------|-------------------------|----|------------|--------|------------|----|---------|----|----------------|--------|-------|-----------------|
|      |        | Constant kVA            |    | Constant Z |        | Constant I |    | Generic |    | MVA            | % PF   | Amp   | Percent Loading |
| ID   | kV     | Rated Amp               | MW | Mvar       | MW     | Mvar       | MW | Mvar    | MW | Mvar           |        |       |                 |
| Bus1 | 66.000 |                         | 0  | 0          | 0      | 0          | 0  | 0       | 0  | 0              | 33.832 | 99.7  | 296.0           |
| Bus2 | 11.000 |                         | 0  | 0          | 33.590 | 0          | 0  | 0       | 0  | 0              | 33.590 | 100.0 | 1775.7          |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000           | 19.332          | 96.7 | 19.194           | 96.0 |
| T2           | Transformer |                 |             |   | 15.000           | 14.499          | 96.7 | 14.396           | 96.0 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- Voltage at 11 kV bus is 99.286%
- No bus is overloaded
- Both transformers T1 and T2 are loaded at 96.7 %

### Scenario 1 – One 11 kV feeder augmented at 66 kV supply

In this scenario, one 11 kV feeder catering to 4 MVA load has been augmented to 66 kV supply and is fed by 66 kV Bus 1.

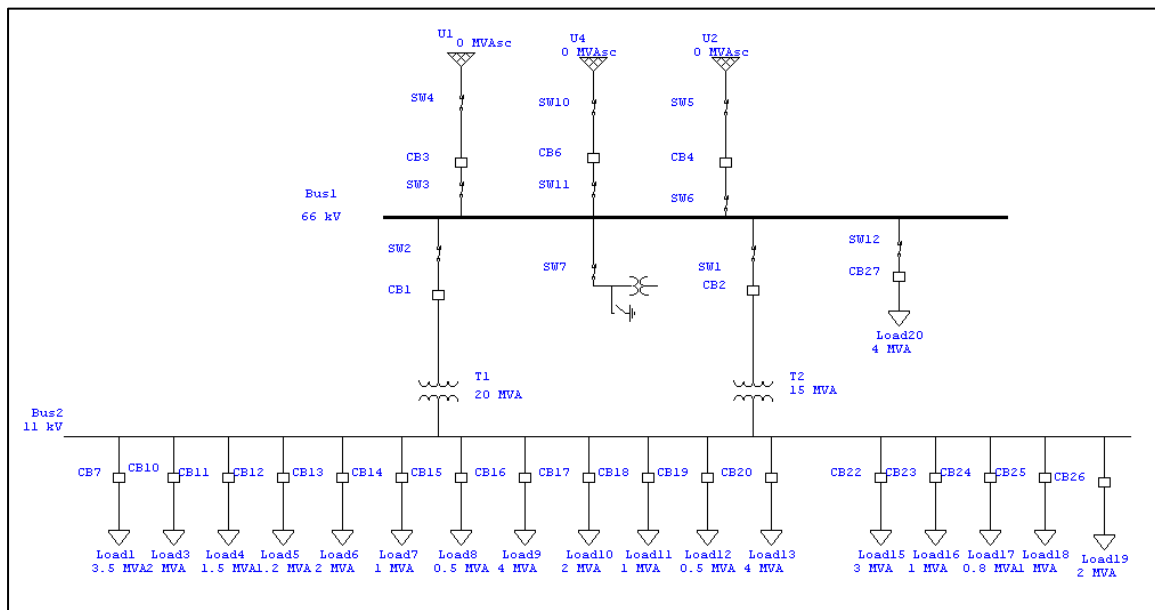


Figure 11 - SLD of Atladara S/s with one feeder augmented at 66 kV supply

Now, load flow can be conducted on the substation as follows –

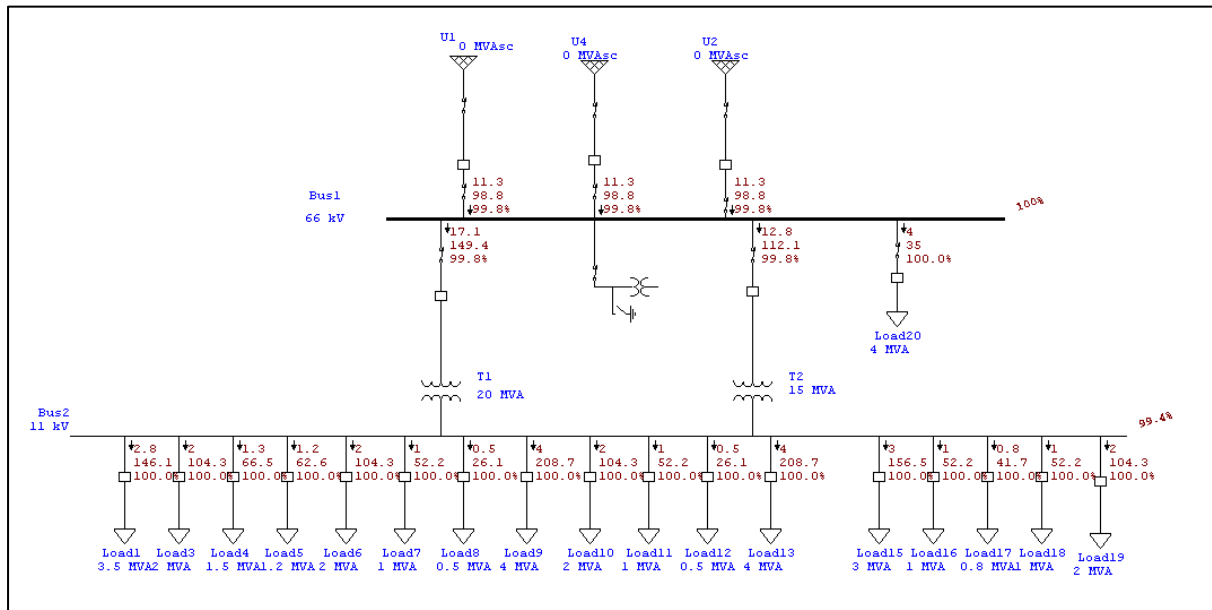


Figure 12 - Load flow study conducted on scenario 1

| LOAD FLOW REPORT                                                                               |        |         |      |            |       |        |       |           |         |       |       |       |      |
|------------------------------------------------------------------------------------------------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| Bus                                                                                            |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
| ID                                                                                             | kV     | % Mag   | Ang  | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1                                                                                         | 66.000 | 100.000 | 0.0  | 33.825     | 2.040 | 4.000  | 0.000 | Bus2      | 17.043  | 1.166 | 149.4 | 99.8  |      |
|                                                                                                |        |         |      |            |       |        |       | Bus2      | 12.782  | 0.874 | 112.1 | 99.8  |      |
| Bus2                                                                                           | 11.000 | 99.400  | -3.9 | 0          | 0     | 29.715 | 0.000 | Bus1      | -16.980 | 0.000 | 896.6 | 100.0 |      |
|                                                                                                |        |         |      |            |       |        |       | Bus1      | -12.735 | 0.000 | 672.5 | 100.0 |      |
| * Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it) |        |         |      |            |       |        |       |           |         |       |       |       |      |
| # Indicates a bus with a load mismatch of more than 0.1 MVA                                    |        |         |      |            |       |        |       |           |         |       |       |       |      |

| Bus Loading Summary Report                                                                                    |        |           |                         |      |            |      |            |      |         |      |                |       |        |                 |
|---------------------------------------------------------------------------------------------------------------|--------|-----------|-------------------------|------|------------|------|------------|------|---------|------|----------------|-------|--------|-----------------|
| Bus                                                                                                           |        |           | Directly Connected Load |      |            |      |            |      |         |      | Total Bus Load |       |        |                 |
|                                                                                                               |        |           | Constant kVA            |      | Constant Z |      | Constant I |      | Generic |      | MVA            | % PF  | Amp    | Percent Loading |
| ID                                                                                                            | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar |                |       |        |                 |
| Bus1                                                                                                          | 66.000 |           | 0                       | 0    | 4.000      | 0    | 0          | 0    | 0       | 0    | 33.886         | 99.8  | 296.4  |                 |
| Bus2                                                                                                          | 11.000 |           | 0                       | 0    | 29.715     | 0    | 0          | 0    | 0       | 0    | 29.715         | 100.0 | 1569.1 |                 |
| * Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating). |        |           |                         |      |            |      |            |      |         |      |                |       |        |                 |
| # Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).  |        |           |                         |      |            |      |            |      |         |      |                |       |        |                 |

| Branch Loading Summary Report                                             |             |                 |             |   |             |                 |      |                  |      |
|---------------------------------------------------------------------------|-------------|-----------------|-------------|---|-------------|-----------------|------|------------------|------|
| CKT / Branch                                                              |             | Cable & Reactor |             |   | Transformer |                 |      |                  |      |
|                                                                           |             |                 |             |   | Capability  | Loading (input) |      | Loading (output) |      |
| ID                                                                        | Type        | Ampacity (Amp)  | Loading Amp | % | (MVA)       | MVA             | %    | MVA              | %    |
| T1                                                                        | Transformer |                 |             |   | 20.000      | 17.083          | 85.4 | 16.980           | 84.9 |
| T2                                                                        | Transformer |                 |             |   | 15.000      | 12.812          | 85.4 | 12.735           | 84.9 |
| * Indicates a branch with operating load exceeding the branch capability. |             |                 |             |   |             |                 |      |                  |      |

### Key observations

- i) Voltage at 11 kV bus has improved from 99.286% to 99.4%
- ii) No bus is overloaded
- iii) Both transformers T1 and T2 are now loaded at 85.4% versus earlier loading of 96.7 %

### Effect of outage on proposed 66 kV feeder

Now, the effect of switching off 66 kV feeder can be observed by keeping CB27 in “Open” condition as follows-

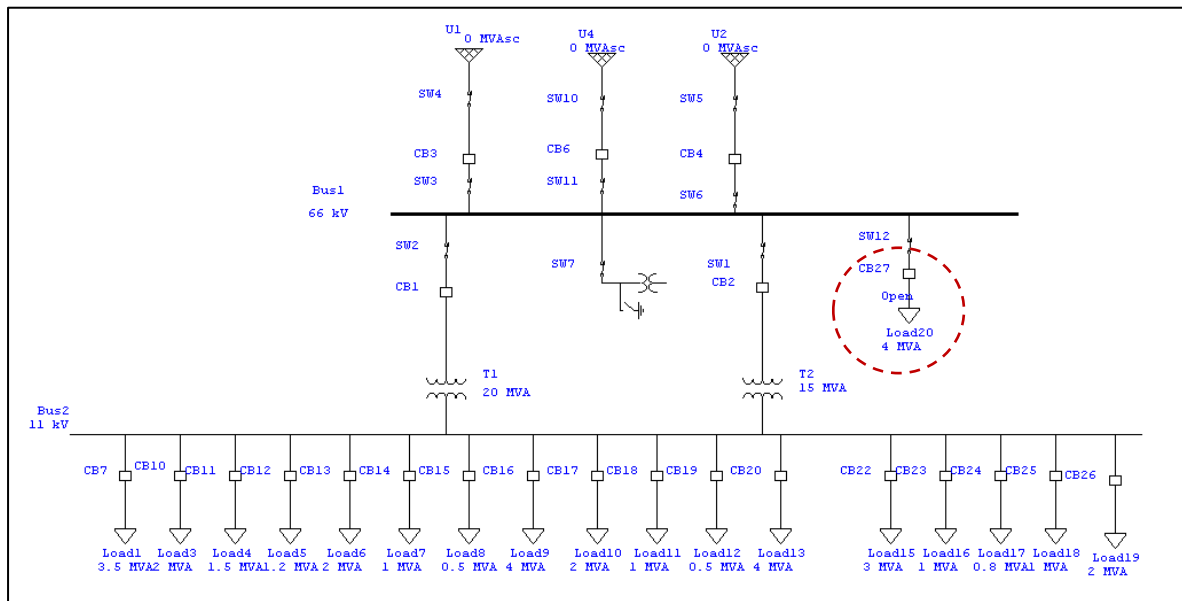
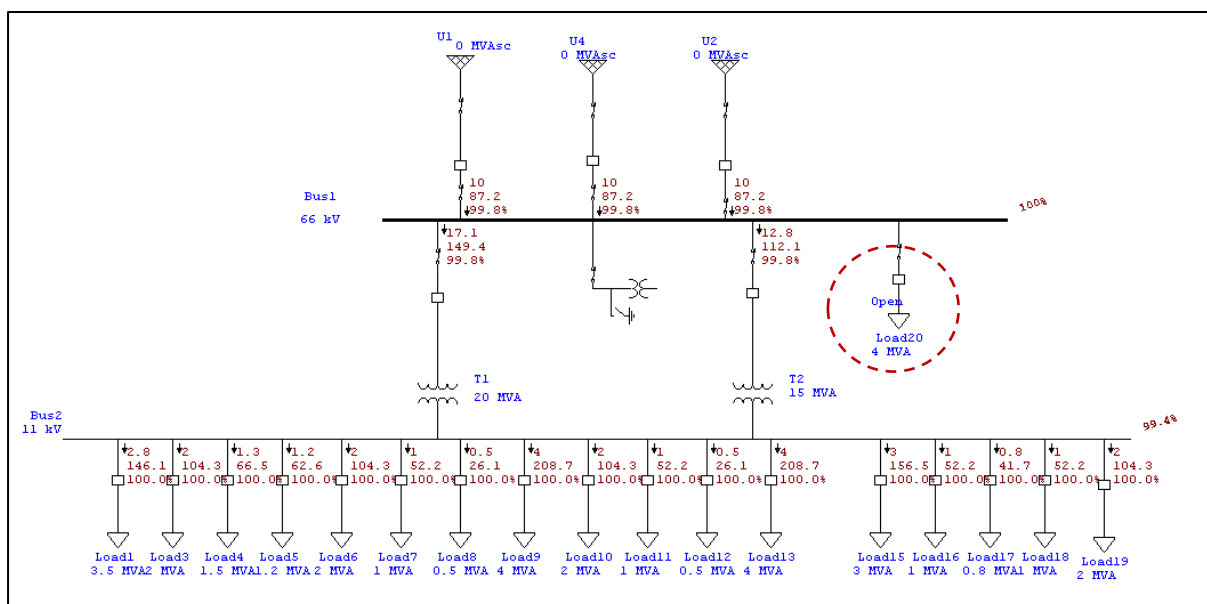


Figure 13 - Scenario 1 SLD with 66 kV CB open

Load flow can be conducted as follows –



Snapshot of load flow report is given as follows –

| <b>LOAD FLOW REPORT</b> |        |         |      |            |       |        |       |           |         |       |       |       |      |  |
|-------------------------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|--|
| Bus                     |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |  |
| ID                      | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |  |
| * Bus1                  | 66.000 | 100.000 | 0.0  | 29.825     | 2.040 | 0      | 0     | Bus2      | 17.043  | 1.166 | 149.4 | 99.8  |      |  |
|                         |        |         |      |            |       |        |       | Bus2      | 12.782  | 0.874 | 112.1 | 99.8  |      |  |
| Bus2                    | 11.000 | 99.400  | -3.9 | 0          | 0     | 29.715 | 0.000 | Bus1      | -16.980 | 0.000 | 896.6 | 100.0 |      |  |
|                         |        |         |      |            |       |        |       | Bus1      | -12.735 | 0.000 | 672.5 | 100.0 |      |  |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)  
# Indicates a bus with a load mismatch of more than 0.1 MVA

| <b>Bus Loading Summary Report</b> |        |                         |              |            |            |         |   |   |   |                |       |        |                 |  |
|-----------------------------------|--------|-------------------------|--------------|------------|------------|---------|---|---|---|----------------|-------|--------|-----------------|--|
| Bus                               |        | Directly Connected Load |              |            |            |         |   |   |   | Total Bus Load |       |        |                 |  |
| ID                                | kV     | Rated Amp               | Constant kVA | Constant Z | Constant I | Generic |   |   |   | MVA            | % PF  | Amp    | Percent Loading |  |
| Bus1                              | 66.000 |                         | 0            | 0          | 0          | 0       | 0 | 0 | 0 | 29.895         | 99.8  | 261.5  |                 |  |
| Bus2                              | 11.000 |                         | 0            | 0          | 29.715     | 0       | 0 | 0 | 0 | 29.715         | 100.0 | 1569.1 |                 |  |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).  
# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| <b>Branch Loading Summary Report</b> |             |                 |             |   |                  |                 |      |                  |      |
|--------------------------------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| CKT / Branch                         |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
| ID                                   | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|                                      |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1                                   | Transformer |                 |             |   | 20.000           | 17.083          | 85.4 | 16.980           | 84.9 |
| T2                                   | Transformer |                 |             |   | 15.000           | 12.812          | 85.4 | 12.735           | 84.9 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- No effect on voltage at 11 kV bus – remains same at 99.4%
- No bus is overloaded
- No obvious effect on loading of transformers T1 and T2 (85.4%)

### Effect of outage on one 11 kV feeder

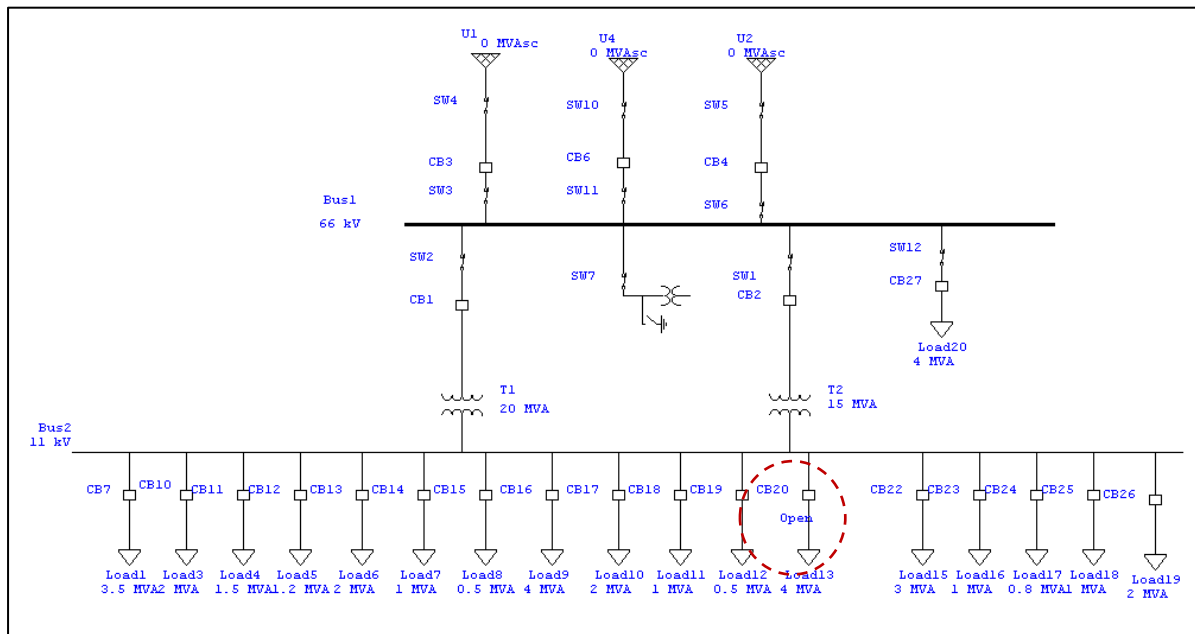
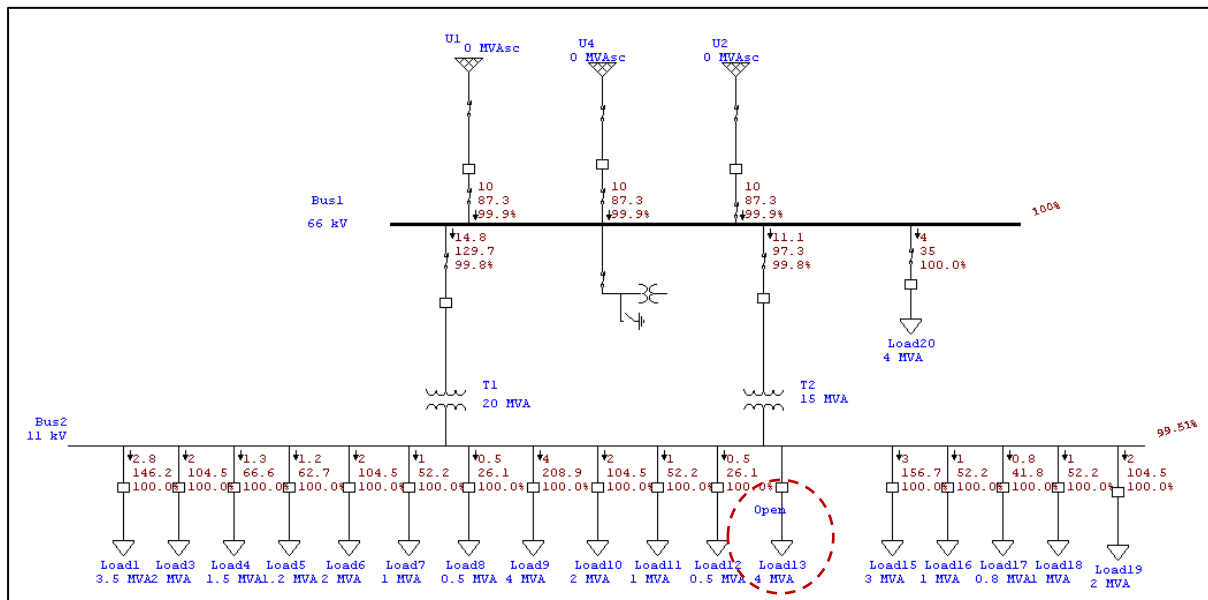


Figure 14 - SLD of scenario 1 with 11 kV CB open

Here, outage on one 11 kV feeder has been simulated by keeping circuit breaker - CB20 in “Open” condition. This effectively cuts off one 4 MVA load from the substation.



Load flow report for the above configuration is as follows –

#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 29.901     | 1.537 | 4.000  | 0.000 | Bus2      | 14.800  | 0.878 | 129.7 | 99.8  |      |
|        |        |         |      |            |       |        |       | Bus2      | 11.100  | 0.659 | 97.3  | 99.8  |      |
| Bus2   | 11.000 | 99.506  | -3.4 | 0          | 0     | 25.818 | 0.000 | Bus1      | -14.753 | 0.000 | 778.2 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -11.065 | 0.000 | 583.6 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)  
# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |              |      |            |      |            |      |         | Total Bus Load |        |       |                 |
|------|--------|-------------------------|--------------|------|------------|------|------------|------|---------|----------------|--------|-------|-----------------|
| ID   | kV     | Rated Amp               | Constant kVA |      | Constant Z |      | Constant I |      | Generic | MVA            | % PF   | Amp   | Percent Loading |
| Bus1 | 66.000 |                         | MW           | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar           |        |       |                 |
|      |        |                         | 0            | 0    | 4.000      | 0    | 0          | 0    | 0       | 0              | 29.940 | 99.9  | 261.9           |
| Bus2 | 11.000 |                         | 0            | 0    | 25.818     | 0    | 0          | 0    | 0       | 0              | 25.818 | 100.0 | 1361.8          |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).  
# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

#### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000           | 14.826          | 74.1 | 14.753           | 73.8 |
| T2           | Transformer |                 |             |   | 15.000           | 11.120          | 74.1 | 11.065           | 73.8 |

\* Indicates a branch with operating load exceeding the branch capability.

#### Key observations

- Voltage at 11 kV bus improved to 99.506% instead of earlier 99.4%
- No bus is overloaded
- Obvious effect on loading of transformers T1 and T2 (reduced to 74.1% from 85.4%)

#### Effect of outage on multiple 11 kV feeders

It can be observed that as we open more and more 11 kV Circuit breakers, the voltage profile at 11 kV bus keeps improving as seen below-

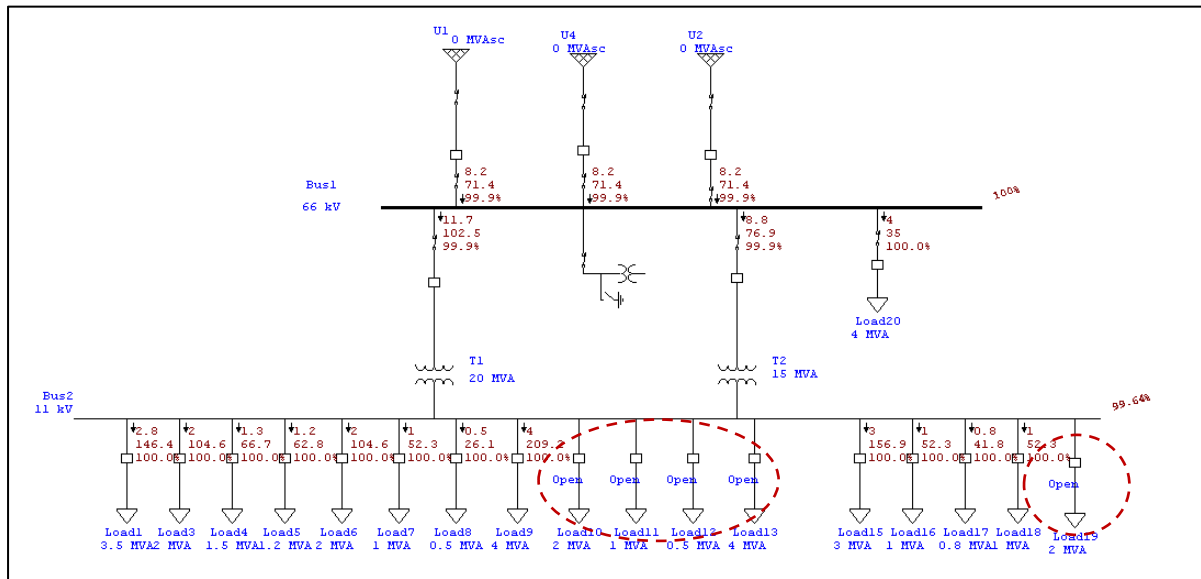


Figure 15 - SLD of scenario 1 with multiple 11 kV CB open

#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 24.478     | 0.959 | 4.000  | 0.000 | Bus2      | 11.702  | 0.348 | 102.5 | 99.9  |      |
|        |        |         |      |            |       |        |       | Bus2      | 8.776   | 0.411 | 76.9  | 99.9  |      |
| Bus2   | 11.000 | 99.639  | -2.7 | 0          | 0     | 20.427 | 0.000 | Bus1      | -11.672 | 0.000 | 614.9 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -8.754  | 0.000 | 461.1 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        |           | Directly Connected Load |      |            |      |            |      |         |      | Total Bus Load |       |        |                 |
|------|--------|-----------|-------------------------|------|------------|------|------------|------|---------|------|----------------|-------|--------|-----------------|
|      |        |           | Constant kVA            |      | Constant Z |      | Constant I |      | Generic |      | MVA            | % PF  | Amp    | Percent Loading |
| ID   | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar |                |       |        |                 |
| Bus1 | 66.000 |           | 0                       | 0    | 4.000      | 0    | 0          | 0    | 0       | 0    | 24.497         | 99.9  | 214.3  |                 |
| Bus2 | 11.000 |           | 0                       | 0    | 20.427     | 0    | 0          | 0    | 0       | 0    | 20.427         | 100.0 | 1076.0 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

#### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
|              |             |                 |             |   | Capability (MVA) | Loading (input) |      | Loading (output) |      |
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000           | 11.715          | 58.6 | 11.672           | 58.4 |
| T2           | Transformer |                 |             |   | 15.000           | 8.786           | 58.6 | 8.754            | 58.4 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- i) Voltage at 11 kV bus improved to 99.639% instead of earlier 99.4% in case of As-Is condition and 99.506% in case of one 11 kV feeder outage
- ii) No bus is overloaded
- iii) Obvious effect on loading of transformers T1 and T2 (reduced to 58.6% from 74.1%) as a result of reduction in load due to outage

### Scenario 2 – Two 11 kV feeders augmented at 66 kV supply

In this scenario, two 11 kV feeders, both catering to 4 MVA loads have been augmented to 66 kV supply as depicted in the SLD below -

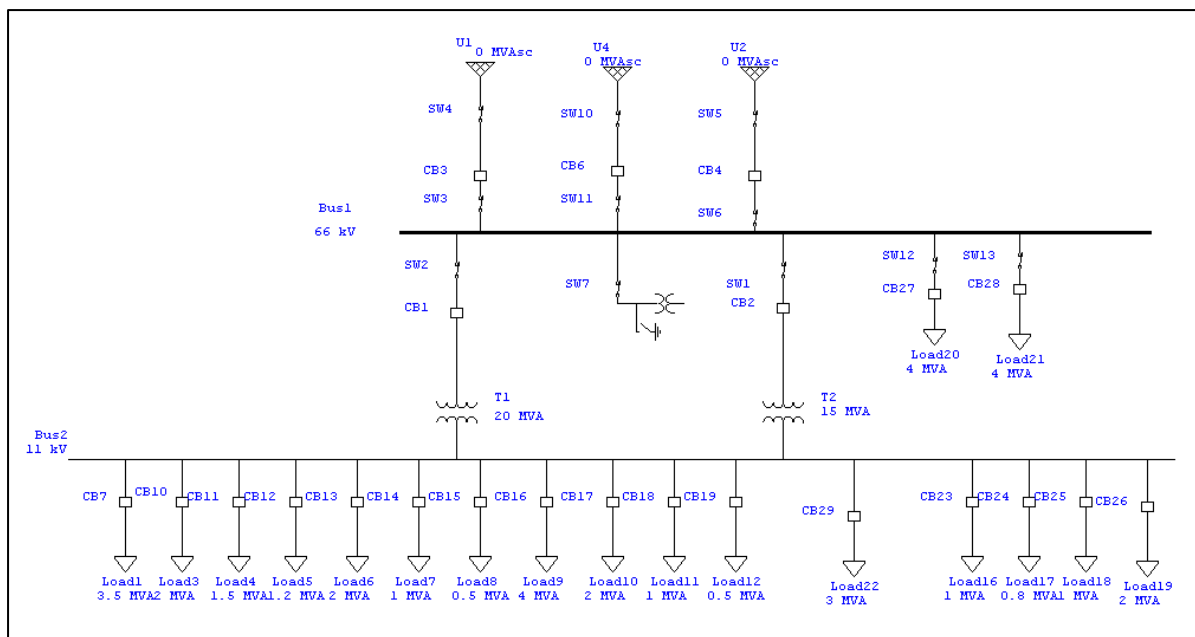
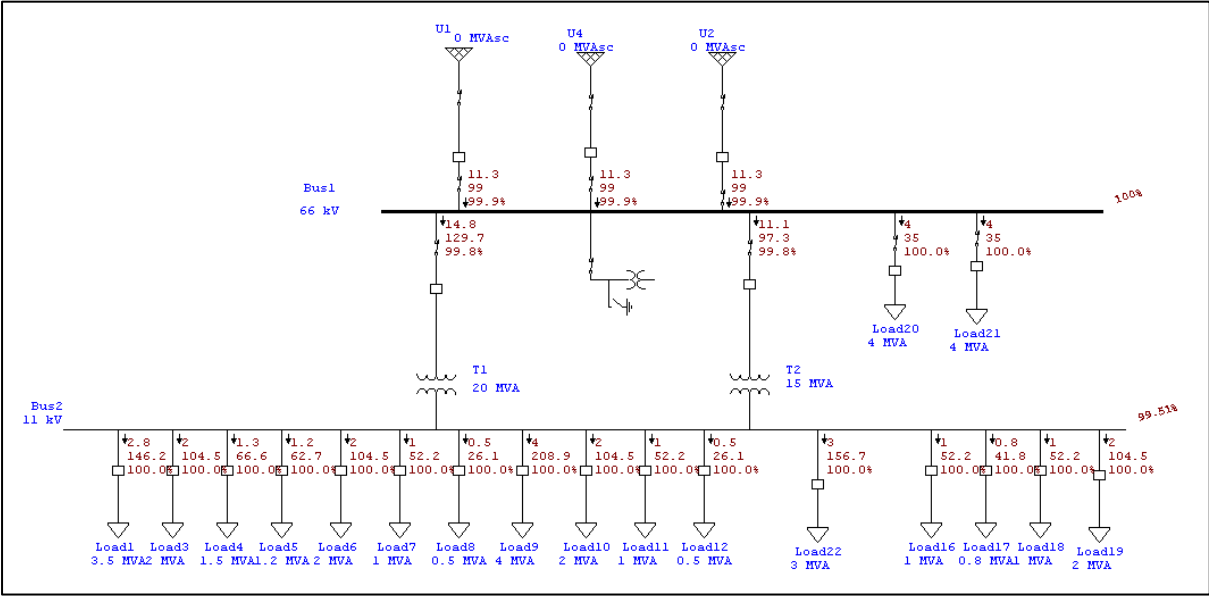


Figure 16 - SLD of scenario 2 at Atladara S/s

Load flow analysis for the same is as follows –



**LOAD FLOW REPORT**

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 33.901     | 1.537 | 8.000  | 0.000 | Bus2      | 14.800  | 0.878 | 129.7 | 99.8  |      |
|        |        |         |      |            |       |        |       | Bus2      | 11.100  | 0.659 | 97.3  | 99.8  |      |
| Bus2   | 11.000 | 99.506  | -3.4 | 0          | 0     | 25.818 | 0.000 | Bus1      | -14.753 | 0.000 | 778.2 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -11.065 | 0.000 | 583.6 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)  
# Indicates a bus with a load mismatch of more than 0.1 MVA

**Bus Loading Summary Report**

| Bus  |        | Directly Connected Load |            |            |         |      |    |      |    | Total Bus Load |        |       |        |                 |
|------|--------|-------------------------|------------|------------|---------|------|----|------|----|----------------|--------|-------|--------|-----------------|
|      |        | Constant kVA            | Constant Z | Constant I | Generic |      |    |      |    |                |        |       |        |                 |
| ID   | kV     | Rated Amp               | MW         | Mvar       | MW      | Mvar | MW | Mvar | MW | Mvar           | MVA    | % PF  | Amp    | Percent Loading |
| Bus1 | 66.000 |                         | 0          | 0          | 8.000   | 0    | 0  | 0    | 0  | 0              | 33.935 | 99.9  | 296.9  |                 |
| Bus2 | 11.000 |                         | 0          | 0          | 25.818  | 0    | 0  | 0    | 0  | 0              | 25.818 | 100.0 | 1361.8 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).  
# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

**Branch Loading Summary Report**

| CKT / Branch |             | Cable & Reactor |             |   | Transformer |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|-------------|-----------------|------|------------------|------|
|              |             |                 |             |   | Capability  | Loading (input) |      | Loading (output) |      |
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | (MVA)       | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000      | 14.826          | 74.1 | 14.753           | 73.8 |
| T2           | Transformer |                 |             |   | 15.000      | 11.120          | 74.1 | 11.065           | 73.8 |

\* Indicates a branch with operating load exceeding the branch capability.

Key observations

- i) Voltage at 11 kV bus is better regulated at 99.506% compared to 99.4% in case of As-Is condition
- ii) No bus is overloaded
- iii) Both transformers T1 and T2 are loaded at 74.1% as 8 MVA load is now shifted to 66 kV level

### Effect of outage on one proposed 66 kV feeder out of two

Now, the effect of switching off one 66 kV feeder can be observed by keeping CB27 in “Open” condition as follows-

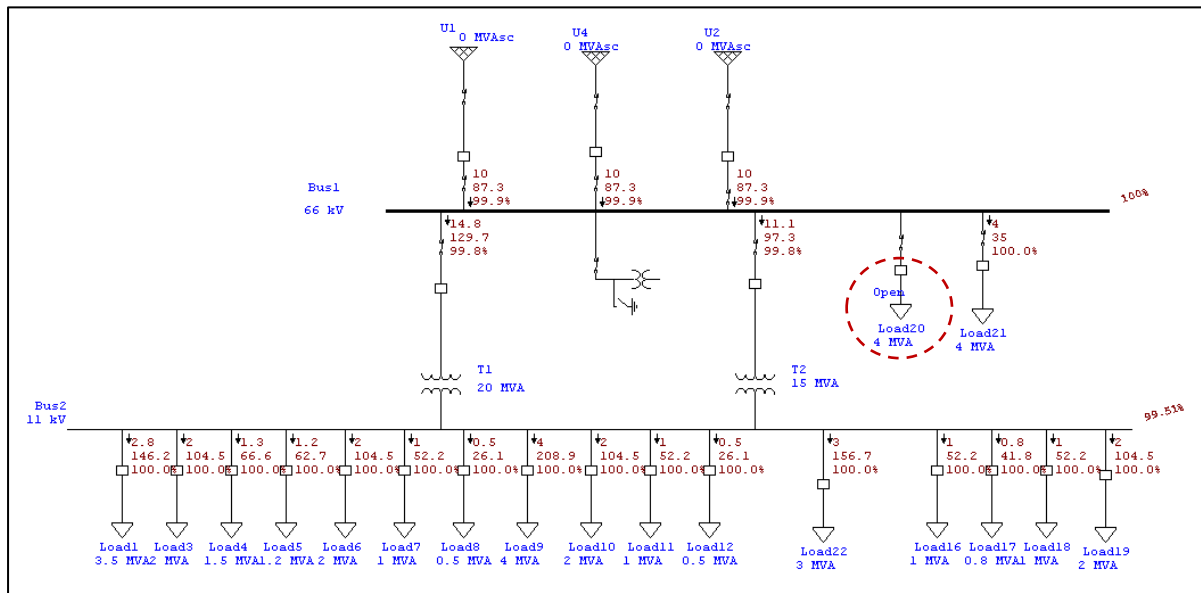


Figure 17 - SLD of scenario 2 with one 66 kV feeder outage

| LOAD FLOW REPORT                                                                               |        |         |      |            |       |        |       |           |         |       |       |       |      |  |
|------------------------------------------------------------------------------------------------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|--|
| Bus                                                                                            |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       |       | XFMR |  |
| ID                                                                                             | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |  |
| * Bus1                                                                                         | 66.000 | 100.000 | 0.0  | 29.901     | 1.537 | 4.000  | 0.000 | Bus2      | 14.800  | 0.878 | 129.7 | 99.8  |      |  |
|                                                                                                |        |         |      |            |       |        |       | Bus2      | 11.100  | 0.659 | 97.3  | 99.8  |      |  |
| Bus2                                                                                           | 11.000 | 99.506  | -3.4 | 0          | 0     | 25.818 | 0.000 | Bus1      | -14.753 | 0.000 | 778.2 | 100.0 |      |  |
|                                                                                                |        |         |      |            |       |        |       | Bus1      | -11.065 | 0.000 | 583.6 | 100.0 |      |  |
| * Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it) |        |         |      |            |       |        |       |           |         |       |       |       |      |  |
| # Indicates a bus with a load mismatch of more than 0.1 MVA                                    |        |         |      |            |       |        |       |           |         |       |       |       |      |  |

| Bus Loading Summary Report                                                                                    |        |                         |            |            |         |      |    |      |    |                |        |       |                 |  |
|---------------------------------------------------------------------------------------------------------------|--------|-------------------------|------------|------------|---------|------|----|------|----|----------------|--------|-------|-----------------|--|
| Bus                                                                                                           |        | Directly Connected Load |            |            |         |      |    |      |    | Total Bus Load |        |       |                 |  |
|                                                                                                               |        | Constant kVA            | Constant Z | Constant I | Generic |      |    |      |    | MVA            | % PF   | Amp   | Percent Loading |  |
| ID                                                                                                            | kV     | Rated Amp               | MW         | Mvar       | MW      | Mvar | MW | Mvar | MW | Mvar           |        |       |                 |  |
| Bus1                                                                                                          | 66.000 |                         | 0          | 0          | 4.000   | 0    | 0  | 0    | 0  | 0              | 29.940 | 99.9  | 261.9           |  |
| Bus2                                                                                                          | 11.000 |                         | 0          | 0          | 25.818  | 0    | 0  | 0    | 0  | 0              | 25.818 | 100.0 | 1361.8          |  |
| * Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating). |        |                         |            |            |         |      |    |      |    |                |        |       |                 |  |
| # Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).  |        |                         |            |            |         |      |    |      |    |                |        |       |                 |  |

| Branch Loading Summary Report |             |                 |             |   |                |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|----------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer    |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capacity (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 20.000         | 14.826          | 74.1 | 14.753           | 73.8 |
| T2                            | Transformer |                 |             |   | 15.000         | 11.120          | 74.1 | 11.065           | 73.8 |

\* Indicates a branch with operating load exceeding the branch capacity.

### Key observations

- No change in voltage at 11 kV bus regulated at 99.506%
- No bus is overloaded
- Both transformers T1 and T2 are loaded at 74.1% as obvious

### Effect of outage on both proposed 66 kV feeders

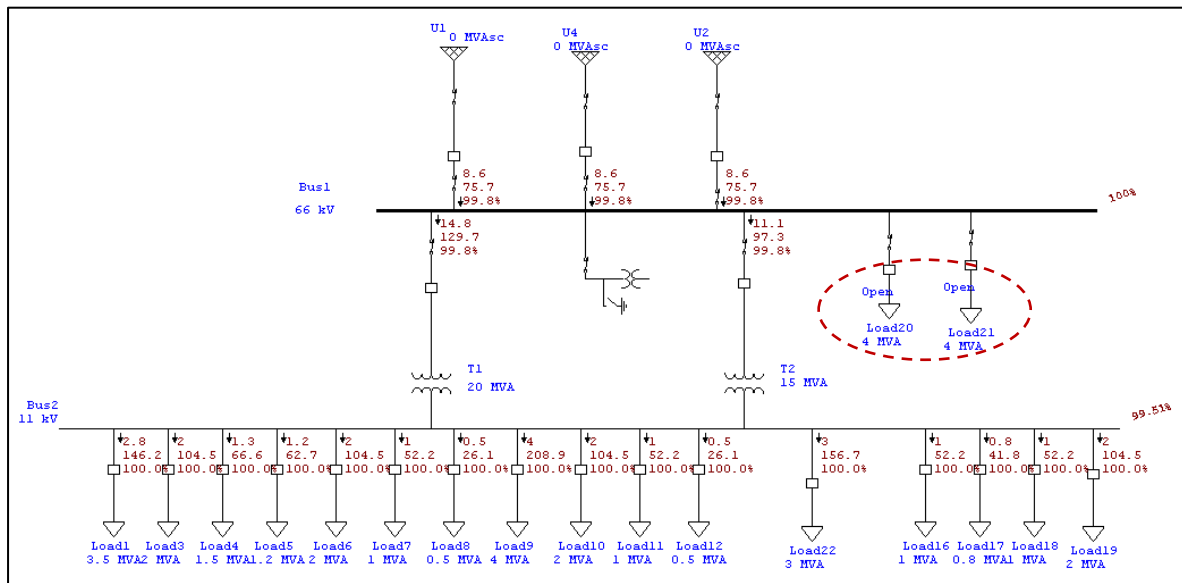


Figure 18 - SLD of scenario 2 with both 66 kV feeder outage

| LOAD FLOW REPORT |        |         |      |            |       |        |       |           |         |       |       |       |      |
|------------------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| Bus              |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
| ID               | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1           | 66.000 | 100.000 | 0.0  | 25.901     | 1.537 | 0      | 0     | Bus2      | 14.800  | 0.878 | 129.7 | 99.8  |      |
|                  |        |         |      |            |       |        |       | Bus2      | 11.100  | 0.659 | 97.3  | 99.8  |      |
| Bus2             | 11.000 | 99.506  | -3.4 | 0          | 0     | 25.818 | 0.000 | Bus1      | -14.753 | 0.000 | 778.2 | 100.0 |      |
|                  |        |         |      |            |       |        |       | Bus1      | -11.065 | 0.000 | 583.6 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

| Bus Loading Summary Report |        |           |                         |      |            |      |            |      |         |      |                |       |        |                 |
|----------------------------|--------|-----------|-------------------------|------|------------|------|------------|------|---------|------|----------------|-------|--------|-----------------|
| Bus                        |        |           | Directly Connected Load |      |            |      |            |      |         |      | Total Bus Load |       |        |                 |
|                            |        |           | Constant kVA            |      | Constant Z |      | Constant I |      | Generic |      | MVA            | % PF  | Amp    | Percent Loading |
| ID                         | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar |                |       |        |                 |
| Bus1                       | 66.000 |           | 0                       | 0    | 0          | 0    | 0          | 0    | 0       | 0    | 25.946         | 99.8  | 227.0  |                 |
| Bus2                       | 11.000 |           | 0                       | 0    | 25.818     | 0    | 0          | 0    | 0       | 0    | 25.818         | 100.0 | 1361.8 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|----------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer    |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capacity (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 20.000         | 14.826          | 74.1 | 14.753           | 73.8 |
| T2                            | Transformer |                 |             |   | 15.000         | 11.120          | 74.1 | 11.065           | 73.8 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- No change in voltage at 11 kV bus regulated at 99.506%
- No bus is overloaded
- Both transformers T1 and T2 are loaded at 74.1% as obvious

### Effect of outage on both proposed 66 kV feeders and one 11 kV feeder

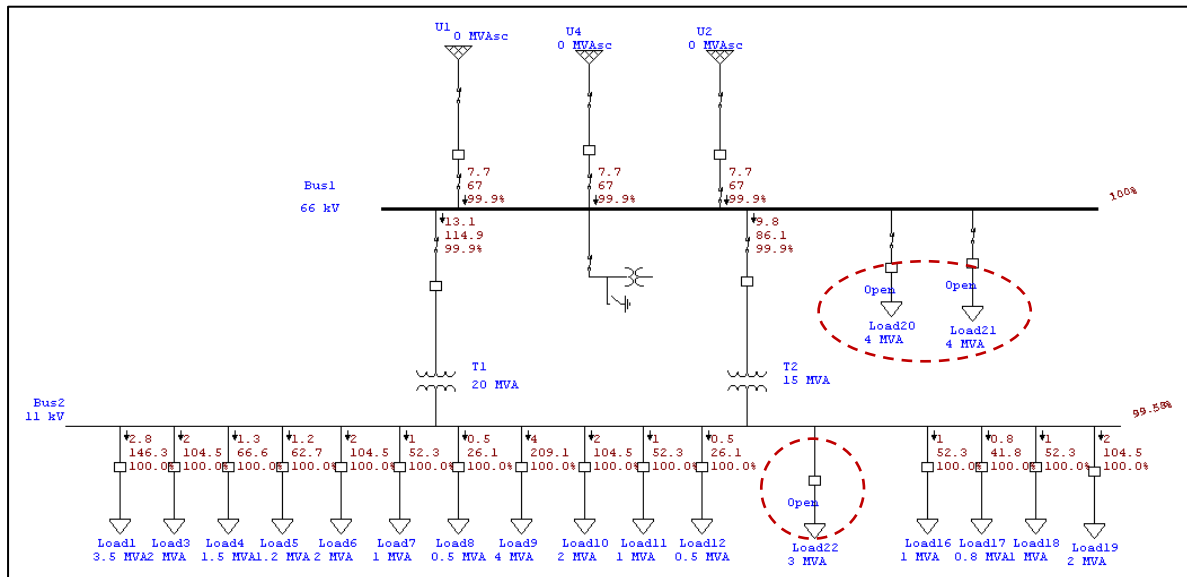


Figure 19 - SLD of scenario 2 with both 66 kV and one 11 kV feeder outage

### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 22.947     | 1.205 | 0      | 0     | Bus2      | 13.112  | 0.689 | 114.9 | 99.9  |      |
|        |        |         |      |            |       |        |       | Bus2      | 9.834   | 0.516 | 86.1  | 99.9  |      |
| Bus2   | 11.000 | 99.580  | -3.0 | 0          | 0     | 22.882 | 0.000 | Bus1      | -13.075 | 0.000 | 689.2 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -9.806  | 0.000 | 516.9 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |              |            |            |         |    |      |    | Total Bus Load |        |       |                 |
|------|--------|-------------------------|--------------|------------|------------|---------|----|------|----|----------------|--------|-------|-----------------|
| ID   | kV     | Rated Amp               | Constant kVA | Constant Z | Constant I | Generic | MW | Mvar | MW | Mvar           | MVA    | % PF  | Percent Loading |
| Bus1 | 66.000 |                         | 0            | 0          | 0          | 0       | 0  | 0    | 0  | 0              | 22.978 | 99.9  | 201.0           |
| Bus2 | 11.000 |                         | 0            | 0          | 22.882     | 0       | 0  | 0    | 0  | 0              | 22.882 | 100.0 | 1206.0          |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000           | 13.130          | 65.7 | 13.075           | 65.4 |
| T2           | Transformer |                 |             |   | 15.000           | 9.848           | 65.7 | 9.806            | 65.4 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- Voltage at 11 kV bus regulated at 99.580 % compared to previous 99.506%
- No bus is overloaded
- Both transformers T1 and T2 are loaded at 65.7% as 11 kV outage has created a reduction in load

### Scenario 3 – Three 11 kV feeders augmented at 66 kV supply

In this scenario, three 11 kV feeders, two catering to 4 MVA loads and one supplying a 3 MVA load have been augmented to 66 kV supply as depicted in the SLD below -

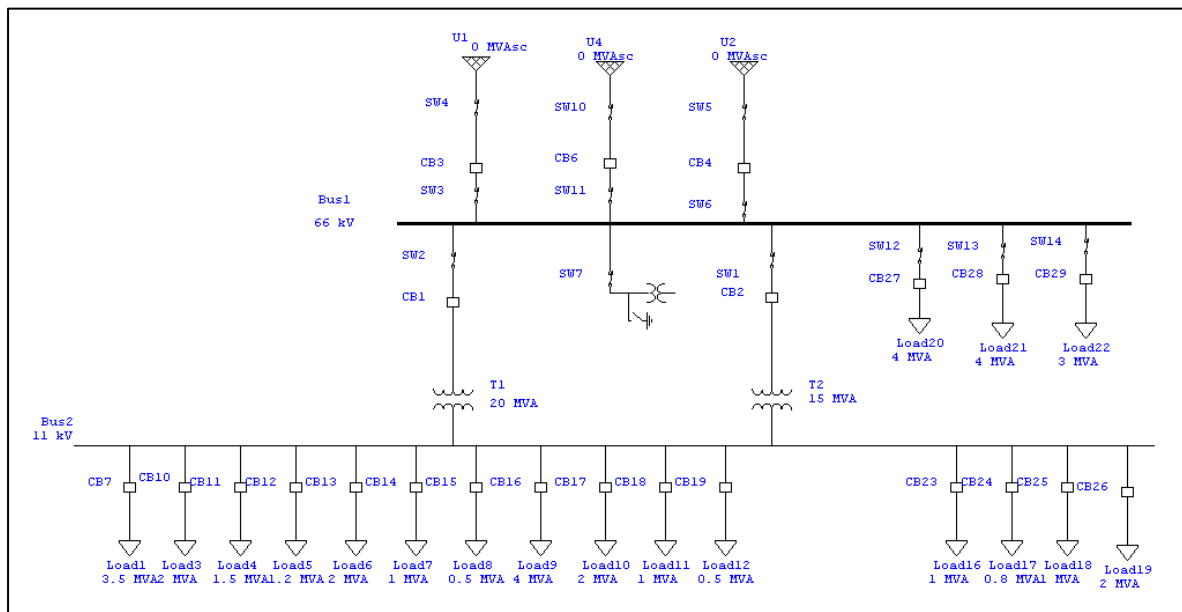
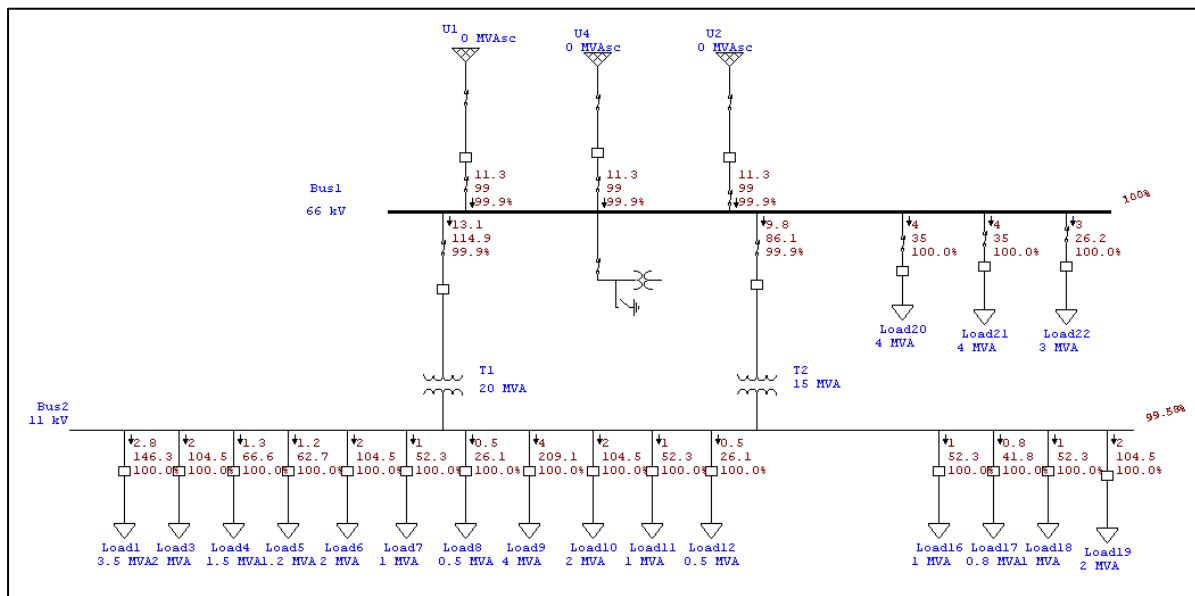


Figure 20 - SLD of scenario 3 at Atladara S/s



#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 33.947     | 1.205 | 11.000 | 0.000 | Bus2      | 13.112  | 0.689 | 114.9 | 99.9  |      |
|        |        |         |      |            |       |        |       | Bus2      | 9.834   | 0.516 | 86.1  | 99.9  |      |
| Bus2   | 11.000 | 99.580  | -3.0 | 0          | 0     | 22.882 | 0.000 | Bus1      | -13.075 | 0.000 | 689.2 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -9.806  | 0.000 | 516.9 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

| Bus Loading Summary Report |        |           |                         |      |            |      |            |      |         |      |                |       |        |                 |
|----------------------------|--------|-----------|-------------------------|------|------------|------|------------|------|---------|------|----------------|-------|--------|-----------------|
| Bus                        |        |           | Directly Connected Load |      |            |      |            |      |         |      | Total Bus Load |       |        |                 |
|                            |        |           | Constant kVA            |      | Constant Z |      | Constant I |      | Generic |      | MVA            | % PF  | Amp    | Percent Loading |
| ID                         | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar |                |       |        |                 |
| Bus1                       | 66.000 |           | 0                       | 0    | 11.000     | 0    | 0          | 0    | 0       | 0    | 33.968         | 99.9  | 297.1  |                 |
| Bus2                       | 11.000 |           | 0                       | 0    | 22.882     | 0    | 0          | 0    | 0       | 0    | 22.882         | 100.0 | 1206.0 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                  |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|                               |             |                 |             |   | Capability (MVA) | Loading (input) |      | Loading (output) |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % |                  | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 20.000           | 13.130          | 65.7 | 13.075           | 65.4 |
| T2                            | Transformer |                 |             |   | 15.000           | 9.848           | 65.7 | 9.806            | 65.4 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus now regulated at 99.580%
- No bus is overloaded
- Both transformers T1 and T2 are loaded at 65.7 %

### Effect of outage on two proposed 66 kV feeders out of three

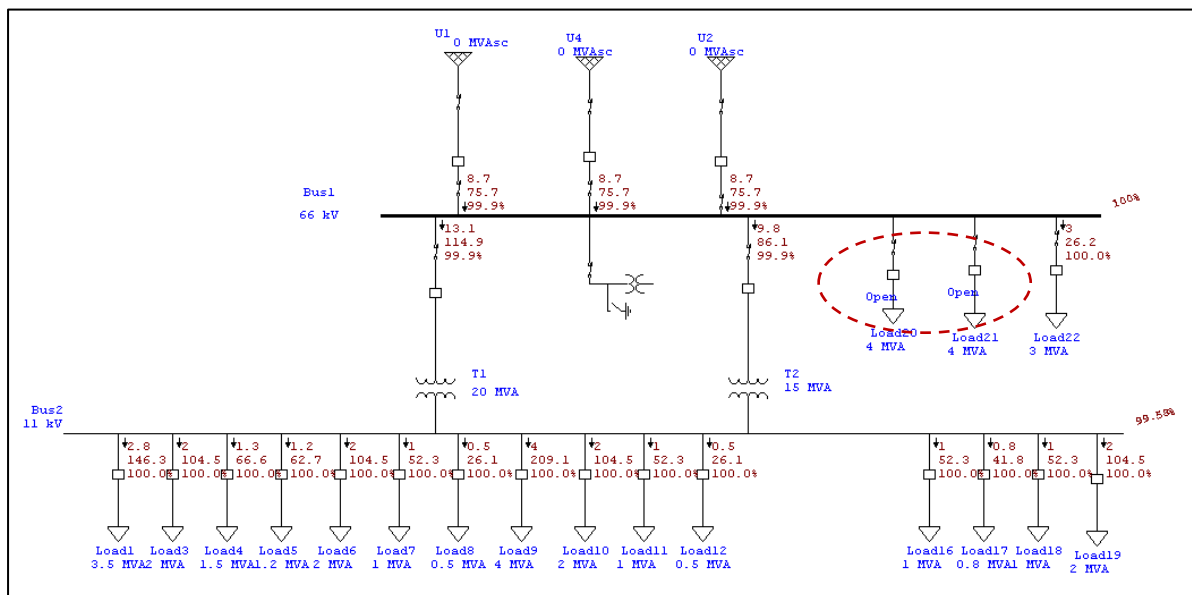


Figure 21 - SLD of scenario 3 with two 66 kV feeder outage

### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 25.947     | 1.205 | 3.000  | 0.000 | Bus2      | 13.112  | 0.689 | 114.9 | 99.9  |      |
|        |        |         |      |            |       |        |       | Bus2      | 9.834   | 0.516 | 86.1  | 99.9  |      |
| Bus2   | 11.000 | 99.580  | -3.0 | 0          | 0     | 22.882 | 0.000 | Bus1      | -13.075 | 0.000 | 689.2 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -9.806  | 0.000 | 516.9 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)  
# Indicates a bus with a load mismatch of more than 0.1 MVA

### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |              |      |            |      |            |      |         | Total Bus Load |      |     |                 |
|------|--------|-------------------------|--------------|------|------------|------|------------|------|---------|----------------|------|-----|-----------------|
| ID   | kV     | Rated Amp               | Constant kVA |      | Constant Z |      | Constant I |      | Generic | MVA            | % PF | Amp | Percent Loading |
| Bus1 | 66.000 |                         | MW           | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar           |      |     |                 |
|      |        |                         |              |      |            |      |            |      |         |                |      |     |                 |
| Bus2 | 11.000 |                         |              |      |            |      |            |      |         |                |      |     |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000           | 13.130          | 65.7 | 13.075           | 65.4 |
| T2           | Transformer |                 |             |   | 15.000           | 9.848           | 65.7 | 9.806            | 65.4 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- No change in 11 kV bus voltage
- No bus is overloaded
- No change in transformer loading

### Effect of outage on all three proposed 66 kV feeders

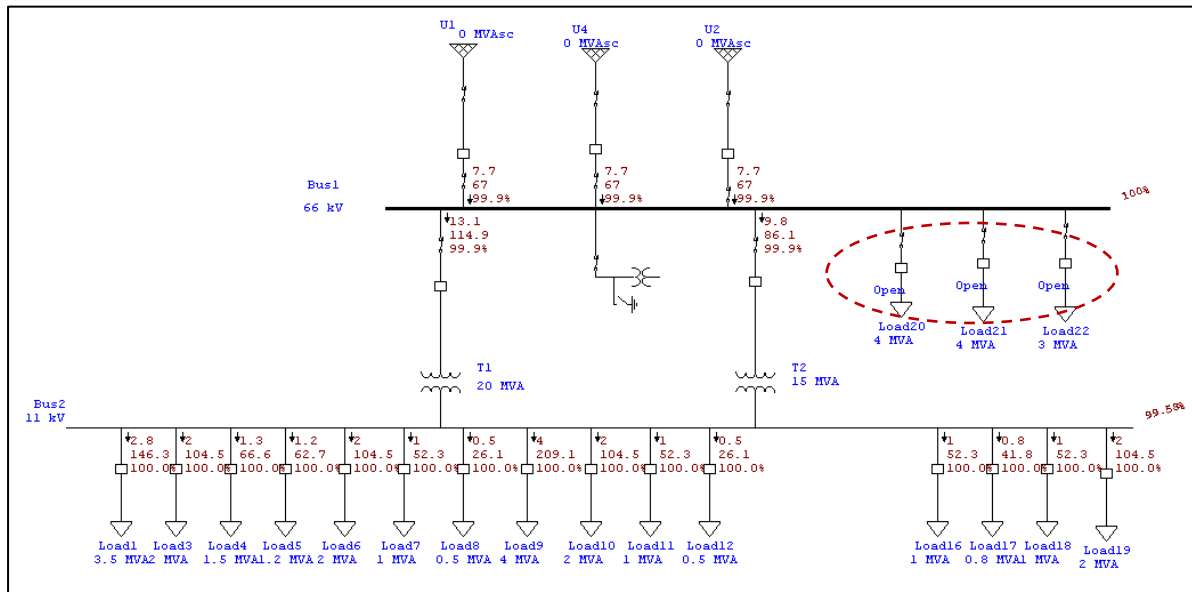


Figure 22 - SLD of scenario 3 with all three 66 kV feeder outage

#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |         |       |       | XFMR  |      |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|---------|-------|-------|-------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW      | Mvar  | Amp   | %PF   | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 22.947     | 1.205 | 0      | 0     | Bus2      | 13.112  | 0.689 | 114.9 | 99.9  |      |
|        |        |         |      |            |       |        |       | Bus2      | 9.834   | 0.516 | 86.1  | 99.9  |      |
| Bus2   | 11.000 | 99.580  | -3.0 | 0          | 0     | 22.882 | 0.000 | Bus1      | -13.075 | 0.000 | 689.2 | 100.0 |      |
|        |        |         |      |            |       |        |       | Bus1      | -9.806  | 0.000 | 516.9 | 100.0 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |            |            |         |              |            |            |         | Total Bus Load |        |       |                 |
|------|--------|-------------------------|------------|------------|---------|--------------|------------|------------|---------|----------------|--------|-------|-----------------|
|      |        | Constant kVA            | Constant Z | Constant I | Generic | Constant kVA | Constant Z | Constant I | Generic | MVA            | % PF   | Amp   | Percent Loading |
| ID   | kV     | Rated Amp               | MW         | Mvar       | MW      | Mvar         | MW         | Mvar       | MW      | Mvar           |        |       |                 |
| Bus1 | 66.000 |                         | 0          | 0          | 0       | 0            | 0          | 0          | 0       | 0              | 22.978 | 99.9  | 201.0           |
| Bus2 | 11.000 |                         | 0          | 0          | 22.882  | 0            | 0          | 0          | 0       | 0              | 22.882 | 100.0 | 1206.0          |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

#### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
|              |             |                 |             |   | Capability (MVA) | Loading (input) |      | Loading (output) |      |
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 20.000           | 13.130          | 65.7 | 13.075           | 65.4 |
| T2           | Transformer |                 |             |   | 15.000           | 9.848           | 65.7 | 9.806            | 65.4 |

\* Indicates a branch with operating load exceeding the branch capability.

#### Key observations

- i) No change in 11 kV bus voltage
- ii) No bus is overloaded
- iii) No change in transformer loading

Effect of outage on all three proposed 66 kV feeders and three 11 kV feeders

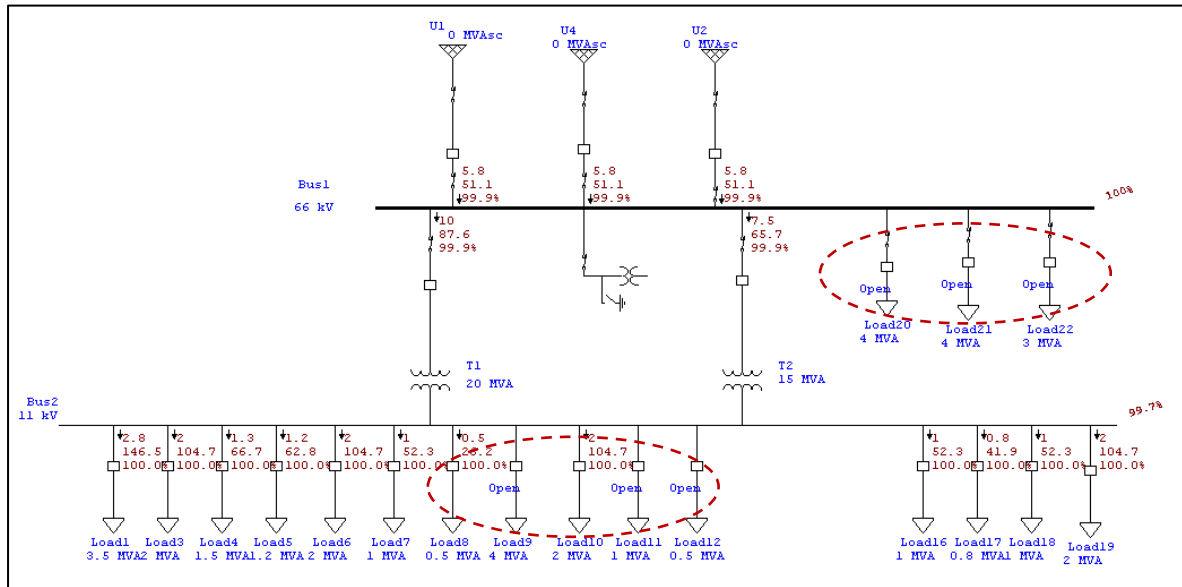


Figure 23 - SLD of scenario 3 with all three 66 kV feeder outage and three 11 kV outage

| LOAD FLOW REPORT |        |         |      |            |       |        |       |           |        |       |       |       |      |  |
|------------------|--------|---------|------|------------|-------|--------|-------|-----------|--------|-------|-------|-------|------|--|
| Bus              |        | Voltage |      | Generation |       | Load   |       | Load Flow |        |       |       | XFMR  |      |  |
| ID               | kV     | % Mag.  | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW     | Mvar  | Amp   | %PF   | %Tap |  |
| * Bus1           | 66.000 | 100.000 | 0.0  | 17.509     | 0.701 | 0      | 0     | Bus2      | 10.005 | 0.400 | 87.6  | 99.9  |      |  |
|                  |        |         |      |            |       |        |       | Bus2      | 7.504  | 0.300 | 65.7  | 99.9  |      |  |
| Bus2             | 11.000 | 99.705  | -2.3 | 0          | 0     | 17.471 | 0.000 | Bus1      | -9.984 | 0.000 | 525.6 | 100.0 |      |  |
|                  |        |         |      |            |       |        |       | Bus1      | -7.488 | 0.000 | 394.2 | 100.0 |      |  |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

| Bus Loading Summary Report |        |                         |            |            |         |              |            |            |         |                |        |       |                 |  |
|----------------------------|--------|-------------------------|------------|------------|---------|--------------|------------|------------|---------|----------------|--------|-------|-----------------|--|
| Bus                        |        | Directly Connected Load |            |            |         |              |            |            |         | Total Bus Load |        |       |                 |  |
|                            |        | Constant kVA            | Constant Z | Constant I | Generic | Constant kVA | Constant Z | Constant I | Generic | MVA            | % PF   | Amp   | Percent Loading |  |
| ID                         | kV     | Rated Amp               | MW         | Mvar       | MW      | Mvar         | MW         | Mvar       | MW      | Mvar           |        |       |                 |  |
| Bus1                       | 66.000 |                         | 0          | 0          | 0       | 0            | 0          | 0          | 0       | 0              | 17.523 | 99.9  | 153.3           |  |
| Bus2                       | 11.000 |                         | 0          | 0          | 17.471  | 0            | 0          | 0          | 0       | 0              | 17.471 | 100.0 | 919.7           |  |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|----------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer    |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capacity (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 20.000         | 10.013          | 50.1 | 9.984            | 49.9 |
| T2                            | Transformer |                 |             |   | 15.000         | 7.510           | 50.1 | 7.488            | 49.9 |

\* Indicates a branch with operating load exceeding the branch capacity.

### Key observations

- 11 kV bus voltage better regulated at 99.705%
- No bus is overloaded
- Transformer loading now only 50.1% due to reduction in 11 kV load

### Effect of outage on three 11 kV feeders

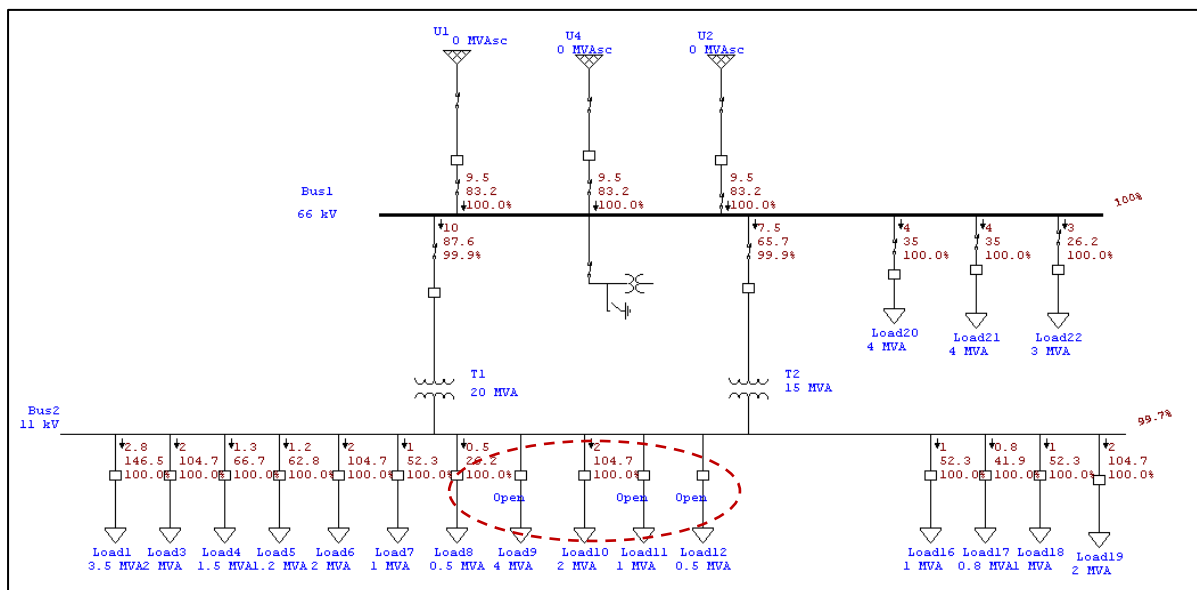


Figure 24 - SLD of scenario 3 with three 11 kV outages

| LOAD FLOW REPORT |        |         |      |            |       |        |       |           |        |       |       |       |      |  |
|------------------|--------|---------|------|------------|-------|--------|-------|-----------|--------|-------|-------|-------|------|--|
| Bus              |        | Voltage |      | Generation |       | Load   |       | Load Flow |        |       |       |       | XFMR |  |
| ID               | kV     | % Mag   | Ang. | MW         | Mvar  | MW     | Mvar  | ID        | MW     | Mvar  | Amp   | %PF   | %Tap |  |
| * Bus1           | 66.000 | 100.000 | 0.0  | 28.509     | 0.701 | 11.000 | 0.000 | Bus2      | 10.005 | 0.400 | 87.6  | 99.9  |      |  |
|                  |        |         |      |            |       |        |       | Bus2      | 7.504  | 0.300 | 65.7  | 99.9  |      |  |
| Bus2             | 11.000 | 99.705  | -2.3 | 0          | 0     | 17.471 | 0.000 | Bus1      | -9.984 | 0.000 | 525.6 | 100.0 |      |  |
|                  |        |         |      |            |       |        |       | Bus1      | -7.488 | 0.000 | 394.2 | 100.0 |      |  |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

| Bus Loading Summary Report |        |           |                         |      |            |      |            |      |         |      |                |       |                 |
|----------------------------|--------|-----------|-------------------------|------|------------|------|------------|------|---------|------|----------------|-------|-----------------|
| Bus                        |        |           | Directly Connected Load |      |            |      |            |      |         |      | Total Bus Load |       |                 |
|                            |        |           | Constant kVA            |      | Constant Z |      | Constant I |      | Generic |      | MVA            | % PF  | Percent Loading |
| ID                         | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar | MW         | Mvar | MW      | Mvar |                |       |                 |
| Bus1                       | 66.000 |           | 0                       | 0    | 11.000     | 0    | 0          | 0    | 0       | 0    | 28.518         | 100.0 | 249.5           |
| Bus2                       | 11.000 |           | 0                       | 0    | 17.471     | 0    | 0          | 0    | 0       | 0    | 17.471         | 100.0 | 919.7           |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                  |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|                               |             |                 |             |   | Capability (MVA) | Loading (input) |      | Loading (output) |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % |                  | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 20.000           | 10.013          | 50.1 | 9.984            | 49.9 |
| T2                            | Transformer |                 |             |   | 15.000           | 7.510           | 50.1 | 7.488            | 49.9 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus voltage better regulated at 99.705%
- No bus is overloaded
- Transformer loading now only 50.1% due to reduction in 11 kV load

## Impact at Icchapore 66 / 11 kV substation

Firstly the current configuration of Icchapore 66 / 11 kV substation has been mapped as a Single Line Diagram on ETAP as follows-

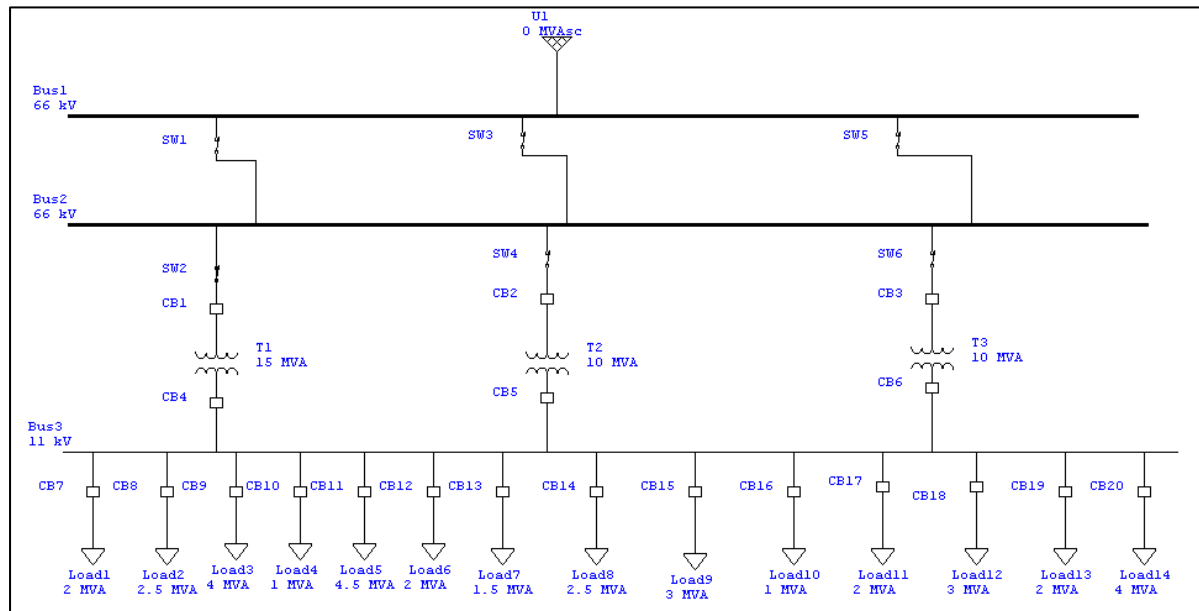
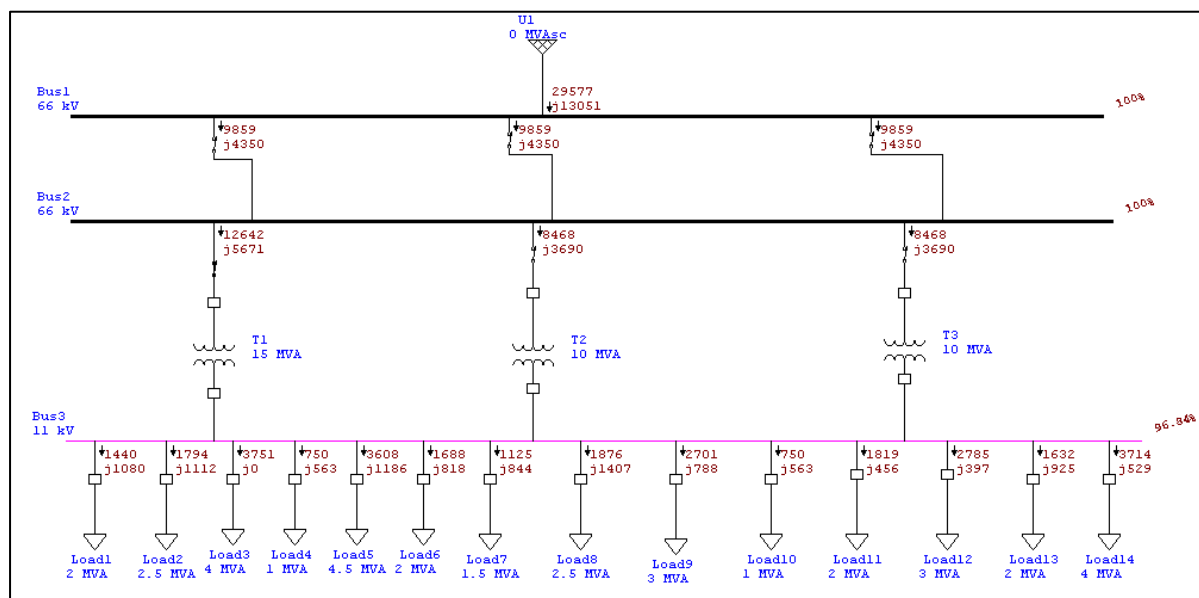


Figure 25 - SLD of Icchapore 66 / 11 kV substation

Now, load flow analysis can be conducted on the substation to see the present as-is condition.



### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |        | Load   |        | Load Flow |         |        |       | XFMR |      |
|--------|--------|---------|------|------------|--------|--------|--------|-----------|---------|--------|-------|------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar   | MW     | Mvar   | ID        | MW      | Mvar   | Amp   | %PF  | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 29.577     | 13.051 | 0      | 0      | Bus2      | 9.859   | 4.350  | 94.3  | 91.5 |      |
|        |        |         |      |            |        |        |        | Bus2      | 9.859   | 4.350  | 94.3  | 91.5 |      |
|        |        |         |      |            |        |        |        | Bus2      | 9.859   | 4.350  | 94.3  | 91.5 |      |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0      | 0      | 0      | Bus3      | 12.642  | 5.671  | 121.2 | 91.2 |      |
|        |        |         |      |            |        |        |        | Bus3      | 8.468   | 3.690  | 80.8  | 91.7 |      |
|        |        |         |      |            |        |        |        | Bus3      | 8.468   | 3.690  | 80.8  | 91.7 |      |
|        |        |         |      |            |        |        |        | Bus1      | -9.859  | -4.350 | 94.3  | 91.5 |      |
|        |        |         |      |            |        |        |        | Bus1      | -9.859  | -4.350 | 94.3  | 91.5 |      |
|        |        |         |      |            |        |        |        | Bus1      | -9.859  | -4.350 | 94.3  | 91.5 |      |
| Bus3   | 11.000 | 96.841  | -3.9 | 0          | 0      | 29.434 | 10.666 | Bus2      | -12.587 | -4.648 | 727.2 | 93.8 |      |
|        |        |         |      |            |        |        |        | Bus2      | -8.424  | -3.009 | 484.8 | 94.2 |      |
|        |        |         |      |            |        |        |        | Bus2      | -8.424  | -3.009 | 484.8 | 94.2 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)  
# Indicates a bus with a load mismatch of more than 0.1 MVA

### Bus Loading Summary Report

| Bus  |        |           | Directly Connected Load |      |            |        |            |      |         |      | Total Bus Load |      |        |                 |
|------|--------|-----------|-------------------------|------|------------|--------|------------|------|---------|------|----------------|------|--------|-----------------|
|      |        |           | Constant kVA            |      | Constant Z |        | Constant I |      | Generic |      | MVA            | % PF | Amp    | Percent Loading |
| ID   | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar   | MW         | Mvar | MW      | Mvar |                |      |        |                 |
| Bus1 | 66.000 |           | 0                       | 0    | 0          | 0      | 0          | 0    | 0       | 0    | 32.329         | 91.5 | 282.8  |                 |
| Bus2 | 66.000 |           | 0                       | 0    | 0          | 0      | 0          | 0    | 0       | 0    | 32.329         | 91.5 | 282.8  |                 |
| Bus3 | 11.000 |           | 0                       | 0    | 29.434     | 10.666 | 0          | 0    | 0       | 0    | 31.307         | 94.0 | 1696.8 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 15.000           | 13.855          | 92.4 | 13.418           | 89.5 |
| T2           | Transformer |                 |             |   | 10.000           | 9.237           | 92.4 | 8.945            | 89.5 |
| T3           | Transformer |                 |             |   | 10.000           | 9.237           | 92.4 | 8.945            | 89.5 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus voltage is regulated at 96.841%
- No bus is overloaded
- All three transformers are loaded at 92.4%

### Scenario 1 – One 11 kV feeder augmented at 66 kV supply

In this scenario, one 11 kV feeder, catering to 4 MVA load has been augmented to 66 kV supply as depicted in the SLD below -

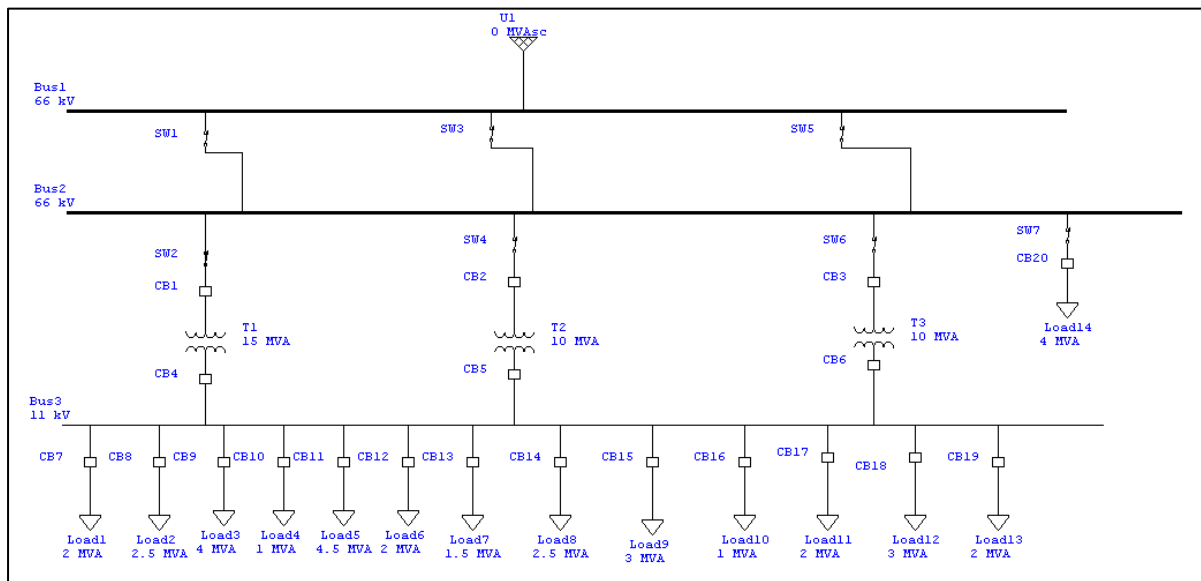
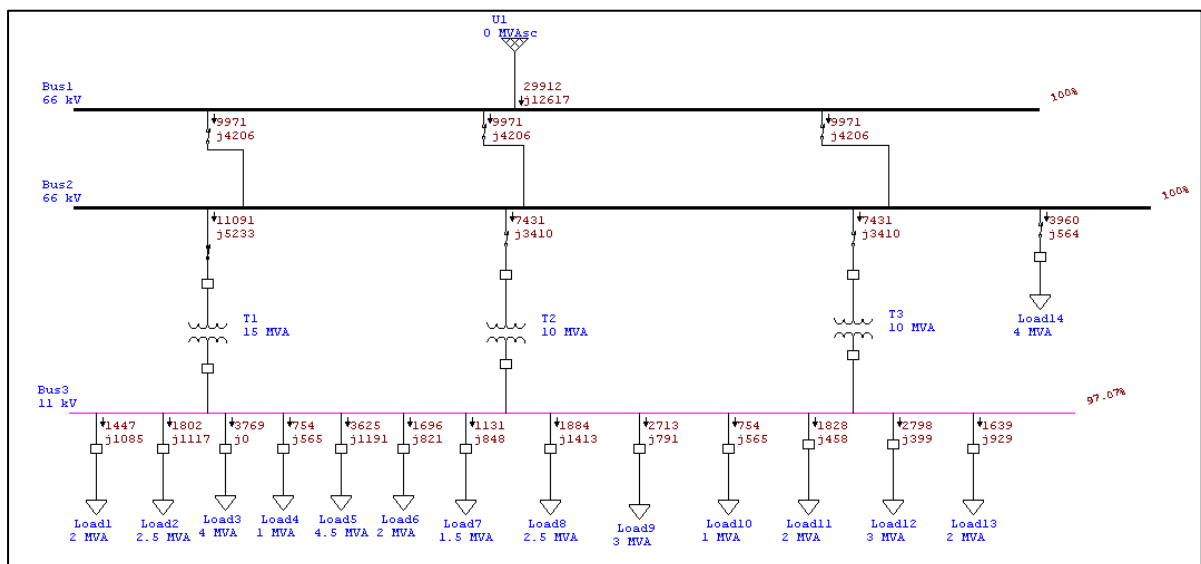


Figure 26 - SLD of Ichapore 66 / 11 kV substation with one 66 kV feeder



#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |        | Load   |        | Load Flow |         |        |       | XFMR |      |
|--------|--------|---------|------|------------|--------|--------|--------|-----------|---------|--------|-------|------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar   | MW     | Mvar   | ID        | MW      | Mvar   | Amp   | %PF  | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 29.912     | 12.617 | 0      | 0      | Bus2      | 9.971   | 4.206  | 94.7  | 92.1 |      |
|        |        |         |      |            |        |        |        | Bus2      | 9.971   | 4.206  | 94.7  | 92.1 |      |
|        |        |         |      |            |        |        |        | Bus2      | 9.971   | 4.206  | 94.7  | 92.1 |      |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0      | 3.960  | 0.564  | Bus3      | 11.091  | 5.233  | 107.3 | 90.4 |      |
|        |        |         |      |            |        |        |        | Bus3      | 7.431   | 3.410  | 71.5  | 90.9 |      |
|        |        |         |      |            |        |        |        | Bus3      | 7.431   | 3.410  | 71.5  | 90.9 |      |
|        |        |         |      |            |        |        |        | Bus1      | -9.971  | -4.206 | 94.7  | 92.1 |      |
|        |        |         |      |            |        |        |        | Bus1      | -9.971  | -4.206 | 94.7  | 92.1 |      |
|        |        |         |      |            |        |        |        | Bus1      | -9.971  | -4.206 | 94.7  | 92.1 |      |
| Bus3   | 11.000 | 97.066  | -3.4 | 0          | 0      | 25.840 | 10.184 | Bus2      | -11.048 | -4.432 | 643.7 | 92.8 |      |
|        |        |         |      |            |        |        |        | Bus2      | -7.396  | -2.876 | 429.1 | 93.2 |      |
|        |        |         |      |            |        |        |        | Bus2      | -7.396  | -2.876 | 429.1 | 93.2 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |    |            |        |            |    |         |    | Total Bus Load |        |      |                 |
|------|--------|-------------------------|----|------------|--------|------------|----|---------|----|----------------|--------|------|-----------------|
|      |        | Constant kVA            |    | Constant Z |        | Constant I |    | Generic |    | MVA            | % PF   | Amp  | Percent Loading |
| ID   | kV     | Rated Amp               | MW | Mvar       | MW     | Mvar       | MW | Mvar    | MW | Mvar           |        |      |                 |
| Bus1 | 66.000 |                         | 0  | 0          | 0      | 0          | 0  | 0       | 0  | 0              | 32.464 | 92.1 | 284.0           |
| Bus2 | 66.000 |                         | 0  | 0          | 3.960  | 0.564      | 0  | 0       | 0  | 0              | 32.464 | 92.1 | 284.0           |
| Bus3 | 11.000 |                         | 0  | 0          | 25.840 | 10.184     | 0  | 0       | 0  | 0              | 27.775 | 93.0 | 1501.9          |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

#### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 15.000           | 12.263          | 81.8 | 11.904           | 79.4 |
| T2           | Transformer |                 |             |   | 10.000           | 8.176           | 81.8 | 7.936            | 79.4 |
| T3           | Transformer |                 |             |   | 10.000           | 8.176           | 81.8 | 7.936            | 79.4 |

\* Indicates a branch with operating load exceeding the branch capability.

#### Key observations

- 11 kV bus voltage is better regulated at 97.066% compared to 96.841% in As-Is case
- No bus is overloaded
- All three transformers are loaded at 81.8% as 4 MVA load has shifted to 66 kV

#### Effect of outage on 66 kV feeder

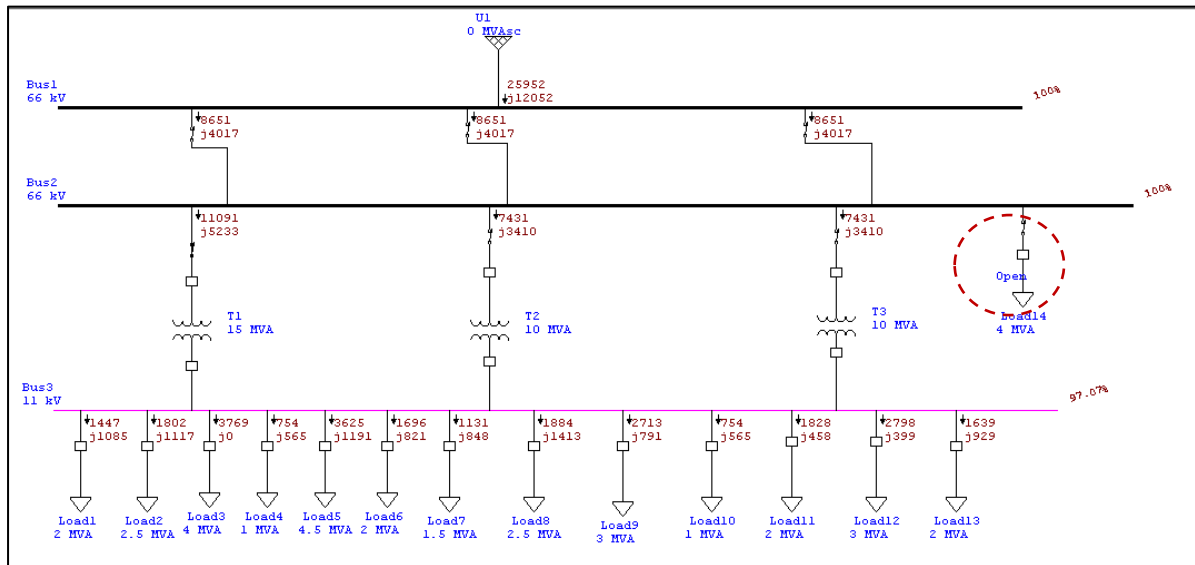


Figure 27 - SLD of Icchapore 66 / 11 kV substation scenario 1 with 66 kV feeder outage

| LOAD FLOW REPORT |        |         |      |        |            |        |        |      |           |        |       |      |      |      |
|------------------|--------|---------|------|--------|------------|--------|--------|------|-----------|--------|-------|------|------|------|
| Bus              |        | Voltage |      |        | Generation |        | Load   |      | Load Flow |        |       |      |      | XFMR |
| ID               | kV     | % Mag   | Ang  | MW     | Mvar       | MW     | Mvar   | ID   | MW        | Mvar   | Amp   | %PF  | %Tap |      |
| * Bus1           | 66.000 | 100.000 | 0.0  | 25.952 | 12.052     | 0      | 0      | Bus2 | 8.651     | 4.017  | 83.4  | 90.7 |      |      |
|                  |        |         |      |        |            |        |        | Bus2 | 8.651     | 4.017  | 83.4  | 90.7 |      |      |
|                  |        |         |      |        |            |        |        | Bus2 | 8.651     | 4.017  | 83.4  | 90.7 |      |      |
| Bus2             | 66.000 | 100.000 | 0.0  | 0      | 0          | 0      | 0      | Bus3 | 11.091    | 5.233  | 107.3 | 90.4 |      |      |
|                  |        |         |      |        |            |        |        | Bus3 | 7.431     | 3.410  | 71.5  | 90.9 |      |      |
|                  |        |         |      |        |            |        |        | Bus3 | 7.431     | 3.410  | 71.5  | 90.9 |      |      |
|                  |        |         |      |        |            |        |        | Bus1 | -8.651    | -4.017 | 83.4  | 90.7 |      |      |
|                  |        |         |      |        |            |        |        | Bus1 | -8.651    | -4.017 | 83.4  | 90.7 |      |      |
|                  |        |         |      |        |            |        |        | Bus1 | -8.651    | -4.017 | 83.4  | 90.7 |      |      |
| Bus3             | 11.000 | 97.066  | -3.4 | 0      | 0          | 25.840 | 10.184 | Bus2 | -11.048   | -4.432 | 643.7 | 92.8 |      |      |
|                  |        |         |      |        |            |        |        | Bus2 | -7.396    | -2.876 | 429.1 | 93.2 |      |      |
|                  |        |         |      |        |            |        |        | Bus2 | -7.396    | -2.876 | 429.1 | 93.2 |      |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

| Bus Loading Summary Report |        |           |                         |      |            |        |            |      |         |      |                |      |        |                 |
|----------------------------|--------|-----------|-------------------------|------|------------|--------|------------|------|---------|------|----------------|------|--------|-----------------|
| Bus                        |        |           | Directly Connected Load |      |            |        |            |      |         |      | Total Bus Load |      |        |                 |
|                            |        |           | Constant kVA            |      | Constant Z |        | Constant I |      | Generic |      | MVA            | % PF | Amp    | Percent Loading |
| ID                         | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar   | MW         | Mvar | MW      | Mvar |                |      |        |                 |
| Bus1                       | 66.000 |           | 0                       | 0    | 0          | 0      | 0          | 0    | 0       | 0    | 28.614         | 90.7 | 250.3  |                 |
| Bus2                       | 66.000 |           | 0                       | 0    | 0          | 0      | 0          | 0    | 0       | 0    | 28.614         | 90.7 | 250.3  |                 |
| Bus3                       | 11.000 |           | 0                       | 0    | 25.840     | 10.184 | 0          | 0    | 0       | 0    | 27.775         | 93.0 | 1501.9 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                  |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 15.000           | 12.263          | 81.8 | 11.904           | 79.4 |
| T2                            | Transformer |                 |             |   | 10.000           | 8.176           | 81.8 | 7.936            | 79.4 |
| T3                            | Transformer |                 |             |   | 10.000           | 8.176           | 81.8 | 7.936            | 79.4 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- i) No change in 11 kV bus voltage
- ii) No bus is overloaded
- iii) No change in transformer loading

### Effect of outage on 66 kV feeder and one 11 kV feeder

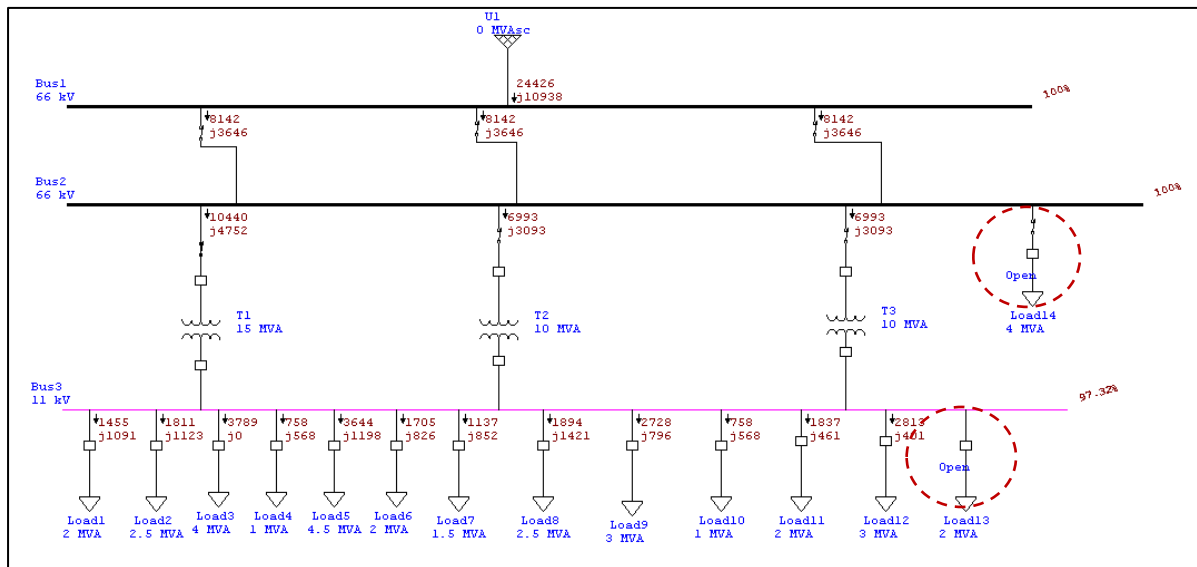


Figure 28 - SLD of Ichhapore 66 / 11 kV substation scenario 1 with 66 kV feeder and one 11 kV feeder outage

#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |        | Load   |       | Load Flow |         |        |       | XFMR |      |
|--------|--------|---------|------|------------|--------|--------|-------|-----------|---------|--------|-------|------|------|
| ID     | kV     | % Mag.  | Ang. | MW         | Mvar   | MW     | Mvar  | ID        | MW      | Mvar   | Amp   | %PF  | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 24.426     | 10.938 | 0      | 0     | Bus2      | 8.142   | 3.646  | 78.0  | 91.3 |      |
|        |        |         |      |            |        |        |       | Bus2      | 8.142   | 3.646  | 78.0  | 91.3 |      |
|        |        |         |      |            |        |        |       | Bus2      | 8.142   | 3.646  | 78.0  | 91.3 |      |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0      | 0      | 0     | Bus3      | 10.440  | 4.752  | 100.3 | 91.0 |      |
|        |        |         |      |            |        |        |       | Bus3      | 6.993   | 3.093  | 66.9  | 91.5 |      |
|        |        |         |      |            |        |        |       | Bus3      | 6.993   | 3.093  | 66.9  | 91.5 |      |
|        |        |         |      |            |        |        |       | Bus1      | -8.142  | -3.646 | 78.0  | 91.3 |      |
|        |        |         |      |            |        |        |       | Bus1      | -8.142  | -3.646 | 78.0  | 91.3 |      |
|        |        |         |      |            |        |        |       | Bus1      | -8.142  | -3.646 | 78.0  | 91.3 |      |
| Bus3   | 11.000 | 97.322  | -3.2 | 0          | 0      | 24.328 | 9.304 | Bus2      | -10.402 | -4.051 | 602.0 | 93.2 |      |
|        |        |         |      |            |        |        |       | Bus2      | -6.963  | -2.626 | 401.4 | 93.6 |      |
|        |        |         |      |            |        |        |       | Bus2      | -6.963  | -2.626 | 401.4 | 93.6 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        |           | Directly Connected Load |      |            |       |            |      |         |      | Total Bus Load |      |        |                 |
|------|--------|-----------|-------------------------|------|------------|-------|------------|------|---------|------|----------------|------|--------|-----------------|
| ID   | kV     | Rated Amp | Constant kVA            |      | Constant Z |       | Constant I |      | Generic |      | MVA            | % PF | Amp    | Percent Loading |
| Bus1 | 66.000 |           | MW                      | Mvar | MW         | Mvar  | MW         | Mvar | MW      | Mvar | 26.764         | 91.3 | 234.1  |                 |
| Bus2 | 66.000 |           | 0                       | 0    | 0          | 0     | 0          | 0    | 0       | 0    | 26.764         | 91.3 | 234.1  |                 |
| Bus3 | 11.000 |           | 0                       | 0    | 24.328     | 9.304 | 0          | 0    | 0       | 0    | 26.047         | 93.4 | 1404.7 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

#### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 15.000           | 11.470          | 76.5 | 11.163           | 74.4 |
| T2           | Transformer |                 |             |   | 10.000           | 7.647           | 76.5 | 7.442            | 74.4 |
| T3           | Transformer |                 |             |   | 10.000           | 7.647           | 76.5 | 7.442            | 74.4 |

\* Indicates a branch with operating load exceeding the branch capability.

#### Key observations

- 11 kV bus voltage is better regulated at 97.332% compared to 96.841% in As-Is case
- No bus is overloaded
- All three transformers are more lightly loaded at 76.5% due to outage at 11 kV

#### Effect of outage on 66 kV feeder and two 11 kV feeder outage

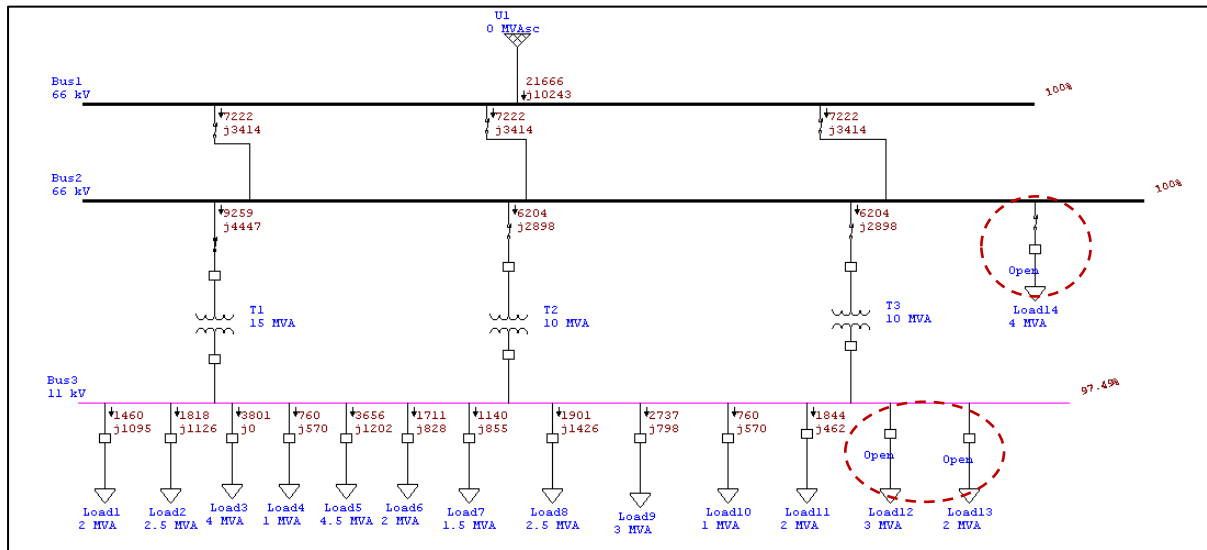


Figure 29 - SLD of Ichhapore 66 / 11 kV substation scenario 1 with 66 kV feeder and two 11 kV feeder outage

| LOAD FLOW REPORT |        |         |      |            |        |        |       |           |        |        |       |      |      |
|------------------|--------|---------|------|------------|--------|--------|-------|-----------|--------|--------|-------|------|------|
| Bus              |        | Voltage |      | Generation |        | Load   |       | Load Flow |        |        |       | XFMR |      |
| ID               | kV     | % Mag   | Ang  | MW         | Mvar   | MW     | Mvar  | ID        | MW     | Mvar   | Amp   | %PF  | %Tap |
| * Bus1           | 66.000 | 100.000 | 0.0  | 21.666     | 10.243 | 0      | 0     | Bus2      | 7.222  | 3.414  | 69.9  | 90.4 |      |
|                  |        |         |      |            |        |        |       | Bus2      | 7.222  | 3.414  | 69.9  | 90.4 |      |
|                  |        |         |      |            |        |        |       | Bus2      | 7.222  | 3.414  | 69.9  | 90.4 |      |
| Bus2             | 66.000 | 100.000 | 0.0  | 0          | 0      | 0      | 0     | Bus3      | 9.259  | 4.447  | 89.8  | 90.1 |      |
|                  |        |         |      |            |        |        |       | Bus3      | 6.204  | 2.898  | 59.9  | 90.6 |      |
|                  |        |         |      |            |        |        |       | Bus3      | 6.204  | 2.898  | 59.9  | 90.6 |      |
|                  |        |         |      |            |        |        |       | Bus1      | -7.222 | -3.414 | 69.9  | 90.4 |      |
|                  |        |         |      |            |        |        |       | Bus1      | -7.222 | -3.414 | 69.9  | 90.4 |      |
|                  |        |         |      |            |        |        |       | Bus1      | -7.222 | -3.414 | 69.9  | 90.4 |      |
| Bus3             | 11.000 | 97.485  | -2.8 | 0          | 0      | 21.588 | 8.933 | Bus2      | -9.228 | -3.885 | 539.1 | 92.2 |      |
|                  |        |         |      |            |        |        |       | Bus2      | -6.180 | -2.524 | 359.4 | 92.6 |      |
|                  |        |         |      |            |        |        |       | Bus2      | -6.180 | -2.524 | 359.4 | 92.6 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

| Bus Loading Summary Report |        |           |                         |      |            |       |            |      |         |      |                |      |        |                 |
|----------------------------|--------|-----------|-------------------------|------|------------|-------|------------|------|---------|------|----------------|------|--------|-----------------|
| Bus                        |        |           | Directly Connected Load |      |            |       |            |      |         |      | Total Bus Load |      |        |                 |
|                            |        |           | Constant kVA            |      | Constant Z |       | Constant I |      | Generic |      | MVA            | % PF | Amp    | Percent Loading |
| ID                         | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar  | MW         | Mvar | MW      | Mvar |                |      |        |                 |
| Bus1                       | 66.000 |           | 0                       | 0    | 0          | 0     | 0          | 0    | 0       | 0    | 23.966         | 90.4 | 209.6  |                 |
| Bus2                       | 66.000 |           | 0                       | 0    | 0          | 0     | 0          | 0    | 0       | 0    | 23.966         | 90.4 | 209.6  |                 |
| Bus3                       | 11.000 |           | 0                       | 0    | 21.588     | 8.933 | 0          | 0    | 0       | 0    | 23.363         | 92.4 | 1257.9 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                  |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 15.000           | 10.271          | 68.5 | 10.013           | 66.8 |
| T2                            | Transformer |                 |             |   | 10.000           | 6.847           | 68.5 | 6.675            | 66.8 |
| T3                            | Transformer |                 |             |   | 10.000           | 6.847           | 68.5 | 6.675            | 66.8 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus voltage is better regulated at 97.485% compared to 96.841% in As-Is case
- No bus is overloaded
- All three transformers are more lightly loaded at 68.5% due to outage at 11 kV

### Scenario 2 – Two 11 kV feeders augmented at 66 kV supply

In this scenario, two 11 kV feeders, one catering to 4.5 MVA load and one supplying a 4 MVA load have been augmented to 66 kV supply as depicted in the SLD below –

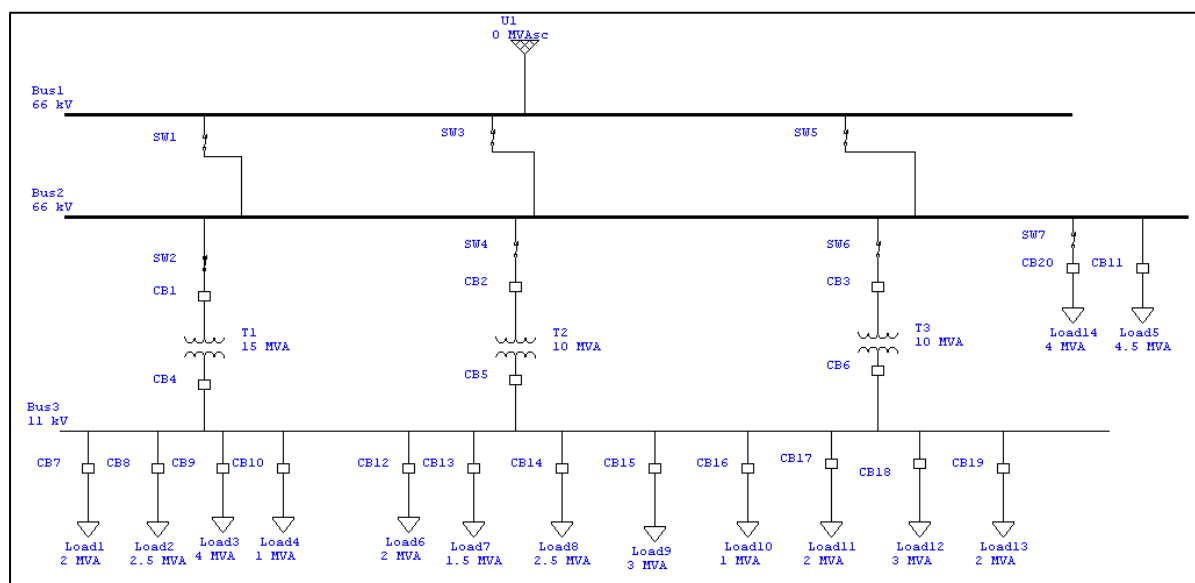
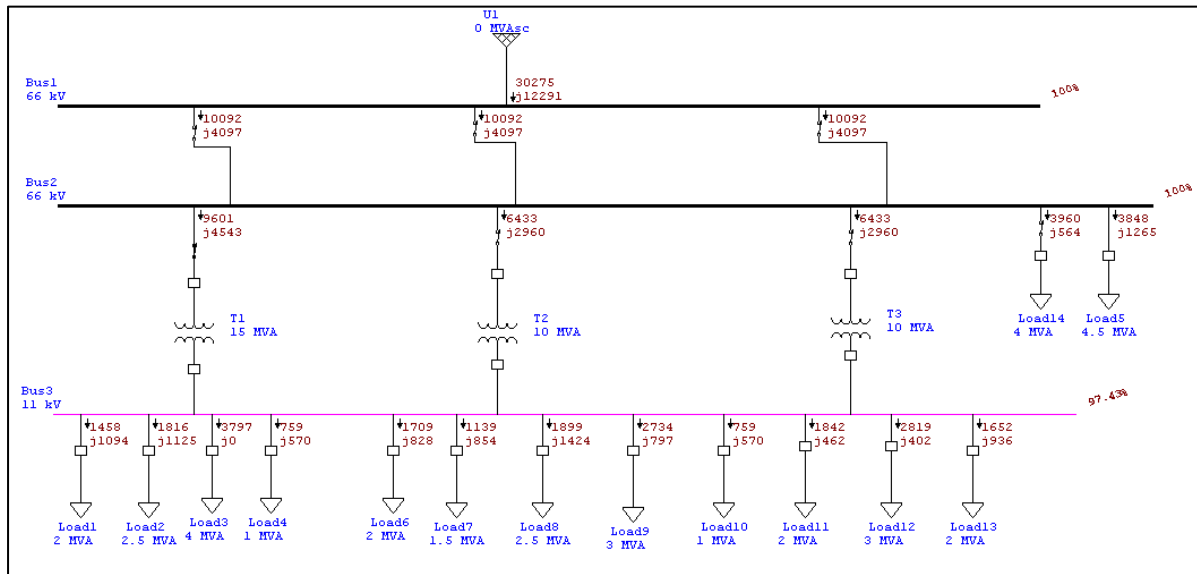


Figure 30 - SLD of Ichhapore 66 / 11 kV substation scenario 2



#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |        | Load   |       | Load Flow |         |        |       | XFMR |      |
|--------|--------|---------|------|------------|--------|--------|-------|-----------|---------|--------|-------|------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar   | MW     | Mvar  | ID        | MW      | Mvar   | Amp   | %PF  | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 30.275     | 12.291 | 0      | 0     | Bus2      | 10.092  | 4.097  | 95.3  | 92.7 |      |
|        |        |         |      |            |        |        |       | Bus2      | 10.092  | 4.097  | 95.3  | 92.7 |      |
|        |        |         |      |            |        |        |       | Bus2      | 10.092  | 4.097  | 95.3  | 92.7 |      |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0      | 7.808  | 1.829 | Bus3      | 9.601   | 4.543  | 92.9  | 90.4 |      |
|        |        |         |      |            |        |        |       | Bus3      | 6.433   | 2.960  | 61.9  | 90.8 |      |
|        |        |         |      |            |        |        |       | Bus3      | 6.433   | 2.960  | 61.9  | 90.8 |      |
|        |        |         |      |            |        |        |       | Bus1      | -10.092 | -4.097 | 95.3  | 92.7 |      |
|        |        |         |      |            |        |        |       | Bus1      | -10.092 | -4.097 | 95.3  | 92.7 |      |
|        |        |         |      |            |        |        |       | Bus1      | -10.092 | -4.097 | 95.3  | 92.7 |      |
| Bus3   | 11.000 | 97.433  | -2.9 | 0          | 0      | 22.384 | 9.061 | Bus2      | -9.569  | -3.942 | 557.5 | 92.5 |      |
|        |        |         |      |            |        |        |       | Bus2      | -6.407  | -2.559 | 371.7 | 92.9 |      |
|        |        |         |      |            |        |        |       | Bus2      | -6.407  | -2.559 | 371.7 | 92.9 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        |           | Directly Connected Load |      |            |       |            |      |         |      | Total Bus Load |      |        |                 |
|------|--------|-----------|-------------------------|------|------------|-------|------------|------|---------|------|----------------|------|--------|-----------------|
|      |        |           | Constant kVA            |      | Constant Z |       | Constant I |      | Generic |      | MVA            | % PF | Amp    | Percent Loading |
| ID   | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar  | MW         | Mvar | MW      | Mvar |                |      |        |                 |
| Bus1 | 66.000 |           | 0                       | 0    | 0          | 0     | 0          | 0    | 0       | 0    | 32.675         | 92.7 | 285.8  |                 |
| Bus2 | 66.000 |           | 0                       | 0    | 7.808      | 1.829 | 0          | 0    | 0       | 0    | 32.675         | 92.7 | 285.8  |                 |
| Bus3 | 11.000 |           | 0                       | 0    | 22.384     | 9.061 | 0          | 0    | 0       | 0    | 24.148         | 92.7 | 1300.8 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|----------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer    |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capacity (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 15.000         | 10.622          | 70.8 | 10.349           | 69.0 |
| T2                            | Transformer |                 |             |   | 10.000         | 7.081           | 70.8 | 6.900            | 69.0 |
| T3                            | Transformer |                 |             |   | 10.000         | 7.081           | 70.8 | 6.900            | 69.0 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus voltage is better regulated at 97.433% compared to 96.841% in As-Is case
- No bus is overloaded
- All three transformers are loaded at 70.8 % as 8.5 MVA load has shifted to 66 kV

### Effect of outage on both 66 kV feeders

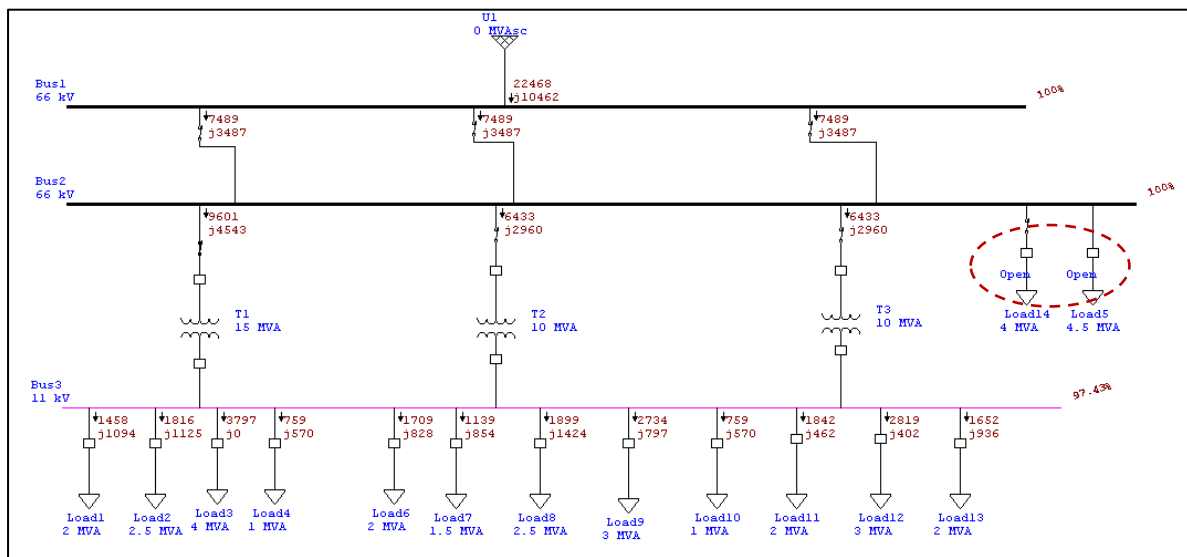


Figure 31 - SLD of Ichhapore 66 / 11 kV substation scenario 2 with both 66 kV feeders off

### LOAD FLOW REPORT

| Bus                                                                                            |        | Voltage |      | Generation |        | Load   |       | Load Flow |        |        |       |      | XFMR |  |
|------------------------------------------------------------------------------------------------|--------|---------|------|------------|--------|--------|-------|-----------|--------|--------|-------|------|------|--|
| ID                                                                                             | kV     | % Mag.  | Ang. | MW         | Mvar   | MW     | Mvar  | ID        | MW     | Mvar   | Amp   | %PF  | %Tap |  |
| * Bus1                                                                                         | 66.000 | 100.000 | 0.0  | 22.468     | 10.462 | 0      | 0     | Bus2      | 7.489  | 3.487  | 72.3  | 90.7 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus2      | 7.489  | 3.487  | 72.3  | 90.7 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus2      | 7.489  | 3.487  | 72.3  | 90.7 |      |  |
| Bus2                                                                                           | 66.000 | 100.000 | 0.0  | 0          | 0      | 0      | 0     | Bus3      | 9.601  | 4.543  | 92.9  | 90.4 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus3      | 6.433  | 2.960  | 61.9  | 90.8 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus3      | 6.433  | 2.960  | 61.9  | 90.8 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus1      | -7.489 | -3.487 | 72.3  | 90.7 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus1      | -7.489 | -3.487 | 72.3  | 90.7 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus1      | -7.489 | -3.487 | 72.3  | 90.7 |      |  |
| Bus3                                                                                           | 11.000 | 97.433  | -2.9 | 0          | 0      | 22.384 | 9.061 | Bus2      | -9.569 | -3.942 | 557.5 | 92.5 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus2      | -6.407 | -2.559 | 371.7 | 92.9 |      |  |
|                                                                                                |        |         |      |            |        |        |       | Bus2      | -6.407 | -2.559 | 371.7 | 92.9 |      |  |
| * Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it) |        |         |      |            |        |        |       |           |        |        |       |      |      |  |
| # Indicates a bus with a load mismatch of more than 0.1 MVA                                    |        |         |      |            |        |        |       |           |        |        |       |      |      |  |

### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |    |            |        |            |    |         |    | Total Bus Load |      |        |                 |
|------|--------|-------------------------|----|------------|--------|------------|----|---------|----|----------------|------|--------|-----------------|
|      |        | Constant kVA            |    | Constant Z |        | Constant I |    | Generic |    | MVA            | % PF | Amp    | Percent Loading |
| ID   | kV     | Rated Amp               | MW | Mvar       | MW     | Mvar       | MW | Mvar    | MW |                |      |        |                 |
| Bus1 | 66.000 |                         | 0  | 0          | 0      | 0          | 0  | 0       | 0  | 24.784         | 90.7 | 216.8  |                 |
| Bus2 | 66.000 |                         | 0  | 0          | 0      | 0          | 0  | 0       | 0  | 24.784         | 90.7 | 216.8  |                 |
| Bus3 | 11.000 |                         | 0  | 0          | 22.384 | 9.061      | 0  | 0       | 0  | 24.148         | 92.7 | 1300.8 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).  
# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 15.000           | 10.622          | 70.8 | 10.349           | 69.0 |
| T2           | Transformer |                 |             |   | 10.000           | 7.081           | 70.8 | 6.900            | 69.0 |
| T3           | Transformer |                 |             |   | 10.000           | 7.081           | 70.8 | 6.900            | 69.0 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- No change in 11 kV bus voltage
- No bus is overloaded
- No change in transformer loading

### Effect of outage on both 66 kV feeders and two 11 kV feeders

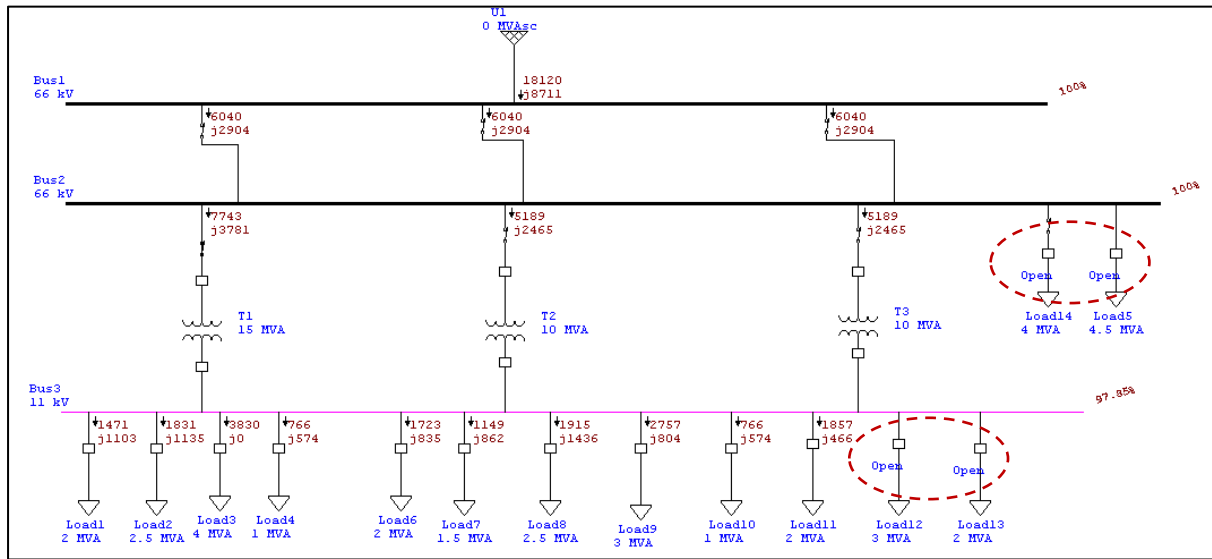


Figure 32 - SLD of Icchapore 66 / 11 kV substation scenario 2 with both 66 kV feeders and two 11 kV outages

### Scenario 3 – Three 11 kV feeders augmented at 66 kV supply

In this scenario, three 11 kV feeders, two catering to 4 MVA loads and one supplying a 4.5 MVA load have been augmented to 66 kV supply as depicted in the SLD below -

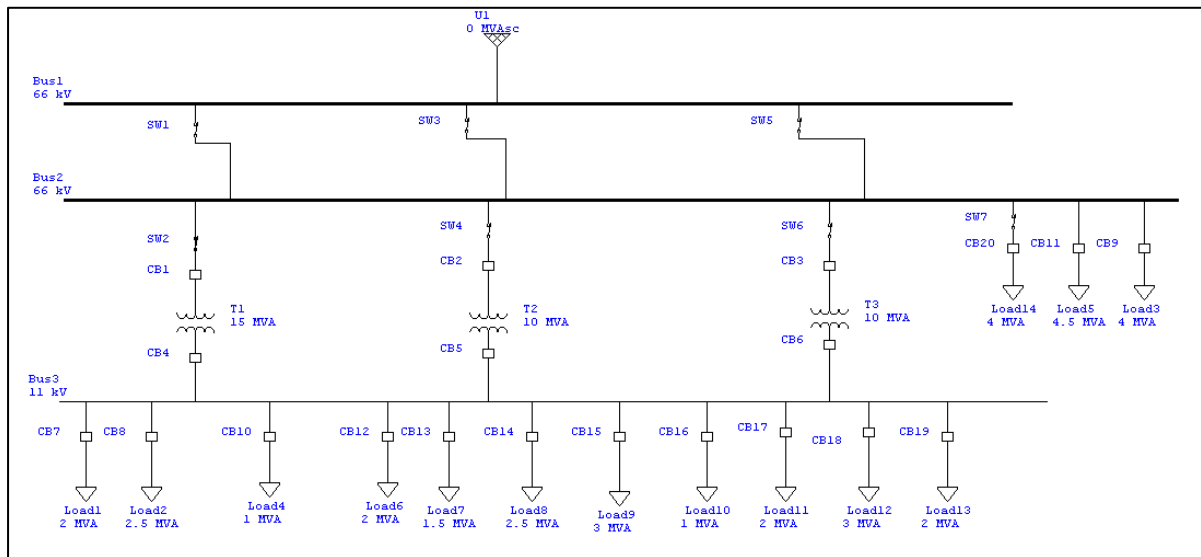
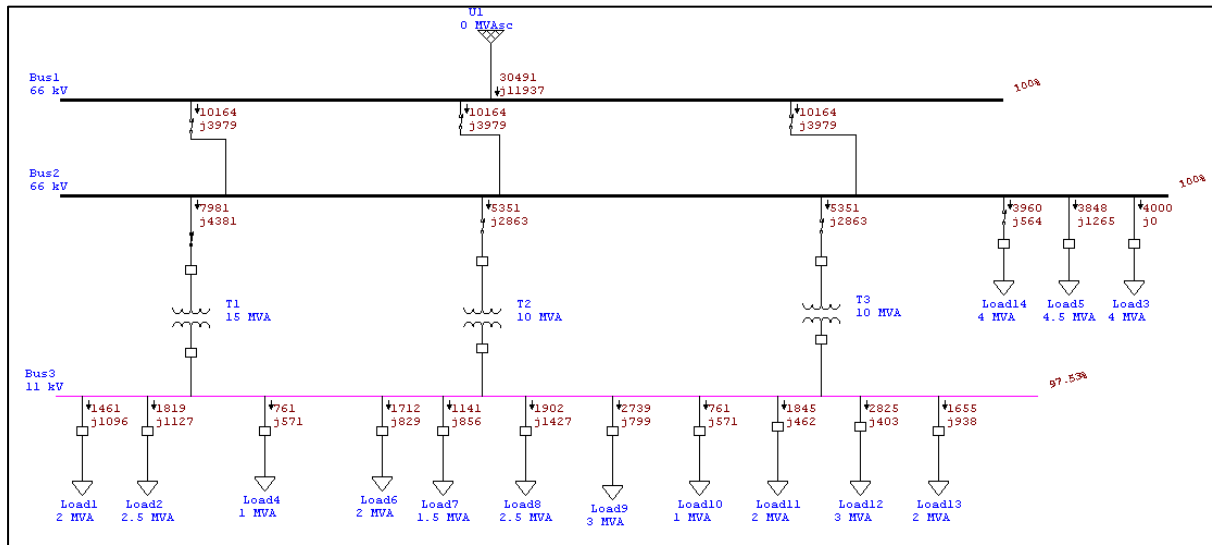


Figure 33 - SLD of Icchapore 66 / 11 kV substation scenario 3



### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |        | Load   |       | Load Flow |         |        |       | XFMR |      |
|--------|--------|---------|------|------------|--------|--------|-------|-----------|---------|--------|-------|------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar   | MW     | Mvar  | ID        | MW      | Mvar   | Amp   | %PF  | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 30.491     | 11.937 | 0      | 0     | Bus2      | 10.164  | 3.979  | 95.5  | 93.1 |      |
|        |        |         |      |            |        |        |       | Bus2      | 10.164  | 3.979  | 95.5  | 93.1 |      |
|        |        |         |      |            |        |        |       | Bus2      | 10.164  | 3.979  | 95.5  | 93.1 |      |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0      | 11.808 | 1.829 | Bus3      | 7.981   | 4.381  | 79.6  | 87.7 |      |
|        |        |         |      |            |        |        |       | Bus3      | 5.351   | 2.863  | 53.1  | 88.2 |      |
|        |        |         |      |            |        |        |       | Bus3      | 5.351   | 2.863  | 53.1  | 88.2 |      |
|        |        |         |      |            |        |        |       | Bus1      | -10.164 | -3.979 | 95.5  | 93.1 |      |
|        |        |         |      |            |        |        |       | Bus1      | -10.164 | -3.979 | 95.5  | 93.1 |      |
|        |        |         |      |            |        |        |       | Bus1      | -10.164 | -3.979 | 95.5  | 93.1 |      |
| Bus3   | 11.000 | 97.526  | -2.4 | 0          | 0      | 18.622 | 9.078 | Bus2      | -7.957  | -3.939 | 477.8 | 89.6 |      |
|        |        |         |      |            |        |        |       | Bus2      | -5.332  | -2.569 | 318.6 | 90.1 |      |
|        |        |         |      |            |        |        |       | Bus2      | -5.332  | -2.569 | 318.6 | 90.1 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

### Bus Loading Summary Report

| Bus  |        |           | Directly Connected Load |      |            |       |            |      |         |      | Total Bus Load |      |        |                 |
|------|--------|-----------|-------------------------|------|------------|-------|------------|------|---------|------|----------------|------|--------|-----------------|
|      |        |           | Constant kVA            |      | Constant Z |       | Constant I |      | Generic |      | MVA            | % PF | Amp    | Percent Loading |
| ID   | kV     | Rated Amp | MW                      | Mvar | MW         | Mvar  | MW         | Mvar | MW      | Mvar |                |      |        |                 |
| Bus1 | 66.000 |           | 0                       | 0    | 0          | 0     | 0          | 0    | 0       | 0    | 32.744         | 93.1 | 286.4  |                 |
| Bus2 | 66.000 |           | 0                       | 0    | 11.808     | 1.829 | 0          | 0    | 0       | 0    | 32.744         | 93.1 | 286.4  |                 |
| Bus3 | 11.000 |           | 0                       | 0    | 18.622     | 9.078 | 0          | 0    | 0       | 0    | 20.717         | 89.9 | 1114.9 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                 |             |   |                  |                 |      |                  |      |
|-------------------------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
| ID                            | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                 |             |   | 15.000           | 9.104           | 60.7 | 8.879            | 59.2 |
| T2                            | Transformer |                 |             |   | 10.000           | 6.069           | 60.7 | 5.919            | 59.2 |
| T3                            | Transformer |                 |             |   | 10.000           | 6.069           | 60.7 | 5.919            | 59.2 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus voltage is regulated at 97.526% compared to 96.841% in As-Is case
- No bus is overloaded
- All three transformers are loaded at only 60.7 % as 12.5 MVA load has shifted to 66 kV

### Effect of outage on all three 66 kV feeders

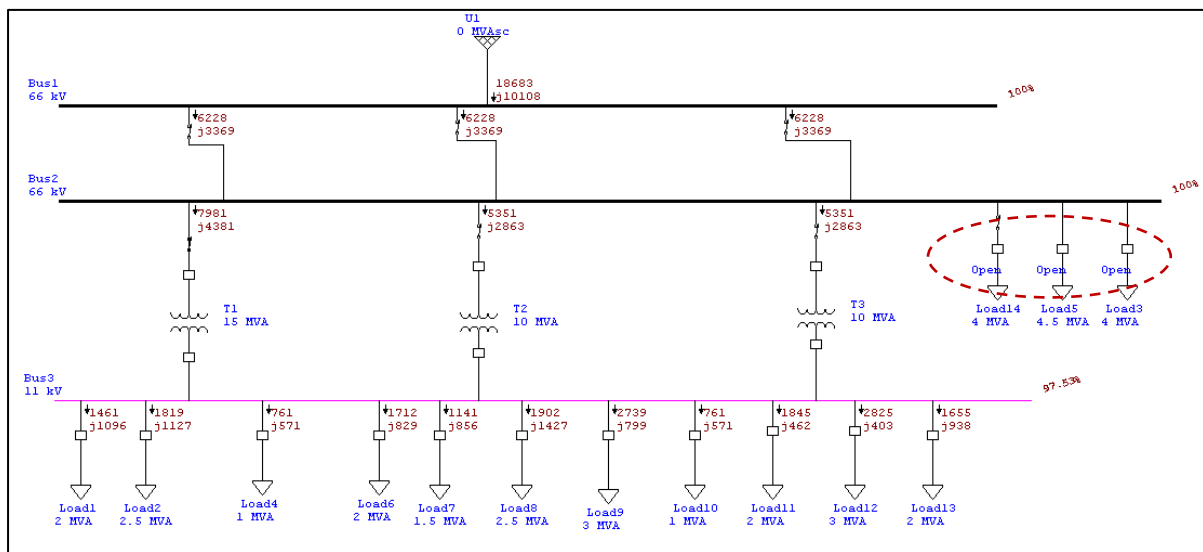


Figure 34 - SLD of Icchapore 66 / 11 kV substation scenario 3 with outage on all three 66 kV feeders

### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |        | Load   |       | Load Flow |        |        |       | XFMR |      |
|--------|--------|---------|------|------------|--------|--------|-------|-----------|--------|--------|-------|------|------|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar   | MW     | Mvar  | ID        | MW     | Mvar   | Amp   | %PF  | %Tap |
| * Bus1 | 66.000 | 100.000 | 0.0  | 18.683     | 10.108 | 0      | 0     | Bus2      | 6.228  | 3.369  | 61.9  | 88.0 |      |
|        |        |         |      |            |        |        |       | Bus2      | 6.228  | 3.369  | 61.9  | 88.0 |      |
|        |        |         |      |            |        |        |       | Bus2      | 6.228  | 3.369  | 61.9  | 88.0 |      |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0      | 0      | 0     | Bus3      | 7.981  | 4.381  | 79.6  | 87.7 |      |
|        |        |         |      |            |        |        |       | Bus3      | 5.351  | 2.863  | 53.1  | 88.2 |      |
|        |        |         |      |            |        |        |       | Bus3      | 5.351  | 2.863  | 53.1  | 88.2 |      |
|        |        |         |      |            |        |        |       | Bus1      | -6.228 | -3.369 | 61.9  | 88.0 |      |
|        |        |         |      |            |        |        |       | Bus1      | -6.228 | -3.369 | 61.9  | 88.0 |      |
|        |        |         |      |            |        |        |       | Bus1      | -6.228 | -3.369 | 61.9  | 88.0 |      |
| Bus3   | 11.000 | 97.526  | -2.4 | 0          | 0      | 18.622 | 9.078 | Bus2      | -7.957 | -3.939 | 477.8 | 89.6 |      |
|        |        |         |      |            |        |        |       | Bus2      | -5.332 | -2.569 | 318.6 | 90.1 |      |
|        |        |         |      |            |        |        |       | Bus2      | -5.332 | -2.569 | 318.6 | 90.1 |      |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

### Bus Loading Summary Report

| Bus  |        |           | Directly Connected Load |   |            |       |            |   |         |   | Total Bus Load |      |        |                 |
|------|--------|-----------|-------------------------|---|------------|-------|------------|---|---------|---|----------------|------|--------|-----------------|
| ID   | kV     | Rated Amp | Constant kVA            |   | Constant Z |       | Constant I |   | Generic |   | MVA            | % PF | Amp    | Percent Loading |
| Bus1 | 66.000 |           | 0                       | 0 | 0          | 0     | 0          | 0 | 0       | 0 | 21.242         | 88.0 | 185.8  |                 |
| Bus2 | 66.000 |           | 0                       | 0 | 0          | 0     | 0          | 0 | 0       | 0 | 21.242         | 88.0 | 185.8  |                 |
| Bus3 | 11.000 |           | 0                       | 0 | 18.622     | 9.078 | 0          | 0 | 0       | 0 | 20.717         | 89.9 | 1114.9 |                 |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

### Branch Loading Summary Report

| CKT / Branch |             | Cable & Reactor |             |   | Transformer      |                 |      |                  |      |
|--------------|-------------|-----------------|-------------|---|------------------|-----------------|------|------------------|------|
| ID           | Type        | Ampacity (Amp)  | Loading Amp | % | Capability (MVA) | Loading (input) |      | Loading (output) |      |
|              |             |                 |             |   |                  | MVA             | %    | MVA              | %    |
| T1           | Transformer |                 |             |   | 15.000           | 9.104           | 60.7 | 8.879            | 59.2 |
| T2           | Transformer |                 |             |   | 10.000           | 6.069           | 60.7 | 5.919            | 59.2 |
| T3           | Transformer |                 |             |   | 10.000           | 6.069           | 60.7 | 5.919            | 59.2 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- No change in 11 kV bus voltage
- No bus is overloaded
- No change in transformer loading

Effect of outage on all three 66 kV feeders and three 11 kV feeders

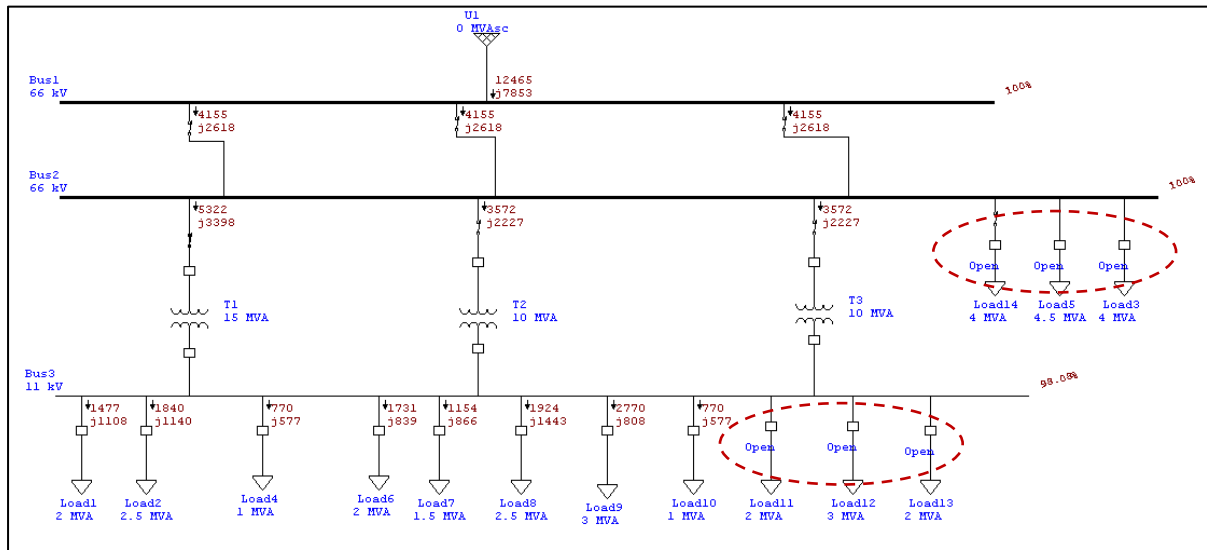


Figure 35 - SLD of Icchapore 66 / 11 kV substation scenario 3 with outage on all three 66 kV & three 11 kV feeders

#### LOAD FLOW REPORT

| Bus    |        | Voltage |      | Generation |       | Load   |       | Load Flow |        |        |       |      | XFMR |  |
|--------|--------|---------|------|------------|-------|--------|-------|-----------|--------|--------|-------|------|------|--|
| ID     | kV     | % Mag   | Ang  | MW         | Mvar  | MW     | Mvar  | ID        | MW     | Mvar   | Amp   | %PF  | %Tap |  |
| * Bus1 | 66.000 | 100.000 | 0.0  | 12.465     | 7.853 | 0      | 0     | Bus2      | 4.155  | 2.618  | 43.0  | 84.6 |      |  |
|        |        |         |      |            |       |        |       | Bus2      | 4.155  | 2.618  | 43.0  | 84.6 |      |  |
|        |        |         |      |            |       |        |       | Bus2      | 4.155  | 2.618  | 43.0  | 84.6 |      |  |
| Bus2   | 66.000 | 100.000 | 0.0  | 0          | 0     | 0      | 0     | Bus3      | 5.322  | 3.398  | 55.2  | 84.3 |      |  |
|        |        |         |      |            |       |        |       | Bus3      | 3.572  | 2.227  | 36.8  | 84.9 |      |  |
|        |        |         |      |            |       |        |       | Bus3      | 3.572  | 2.227  | 36.8  | 84.9 |      |  |
|        |        |         |      |            |       |        |       | Bus1      | -4.155 | -2.618 | 43.0  | 84.6 |      |  |
|        |        |         |      |            |       |        |       | Bus1      | -4.155 | -2.618 | 43.0  | 84.6 |      |  |
|        |        |         |      |            |       |        |       | Bus1      | -4.155 | -2.618 | 43.0  | 84.6 |      |  |
| Bus3   | 11.000 | 98.076  | -1.6 | 0          | 0     | 12.436 | 7.358 | Bus2      | -5.310 | -3.186 | 331.4 | 85.8 |      |  |
|        |        |         |      |            |       |        |       | Bus2      | -3.563 | -2.086 | 220.9 | 86.3 |      |  |
|        |        |         |      |            |       |        |       | Bus2      | -3.563 | -2.086 | 220.9 | 86.3 |      |  |

\* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

#### Bus Loading Summary Report

| Bus  |        | Directly Connected Load |            |            |         |       |    |      |    | Total Bus Load |        |      |                 |
|------|--------|-------------------------|------------|------------|---------|-------|----|------|----|----------------|--------|------|-----------------|
|      |        | Constant kVA            | Constant Z | Constant I | Generic |       |    |      |    | MVA            | % PF   | Amp  | Percent Loading |
| ID   | kV     | Rated Amp               | MW         | Mvar       | MW      | Mvar  | MW | Mvar | MW | Mvar           |        |      |                 |
| Bus1 | 66.000 |                         | 0          | 0          | 0       | 0     | 0  | 0    | 0  | 0              | 14.733 | 84.6 | 128.9           |
| Bus2 | 66.000 |                         | 0          | 0          | 0       | 0     | 0  | 0    | 0  | 0              | 14.733 | 84.6 | 128.9           |
| Bus3 | 11.000 |                         | 0          | 0          | 12.436  | 7.358 | 0  | 0    | 0  | 0              | 14.449 | 86.1 | 773.3           |

\* Indicates operating load of a bus exceeds the bus critical limit ( 100.0% of the Continuous Ampere rating).

# Indicates operating load of a bus exceeds the bus marginal limit ( 95.0% of the Continuous Ampere rating).

| Branch Loading Summary Report |             |                   |                |   |                     |                 |      |                  |      |
|-------------------------------|-------------|-------------------|----------------|---|---------------------|-----------------|------|------------------|------|
| CKT / Branch                  |             | Cable & Reactor   |                |   | Transformer         |                 |      |                  |      |
| ID                            | Type        | Ampacity<br>(Amp) | Loading<br>Amp | % | Capability<br>(MVA) | Loading (input) |      | Loading (output) |      |
|                               |             |                   |                |   |                     | MVA             | %    | MVA              | %    |
| T1                            | Transformer |                   |                |   | 15.000              | 6.314           | 42.1 | 6.193            | 41.3 |
| T2                            | Transformer |                   |                |   | 10.000              | 4.209           | 42.1 | 4.128            | 41.3 |
| T3                            | Transformer |                   |                |   | 10.000              | 4.209           | 42.1 | 4.128            | 41.3 |

\* Indicates a branch with operating load exceeding the branch capability.

### Key observations

- 11 kV bus voltage is regulated at 98.076% compared to 96.841% in As-Is case
- No bus is overloaded
- All three transformers are loaded at only 42.1 % as three 11 kV feeders are in shutdown mode

## Conclusion from technical impact study

Conversion of existing 11 kV consumers to 66 kV supply voltage is technically feasible. Observations from the study suggests that as part of existing load is being shifted to 66 kV, therefore, the 11 kV bus voltage shall improve. Once shifted to 66 kV, it will have no impact on 11 kV and downstream or on power transformers. Feeders at 11 kV level will continue to affect voltage regulation. Therefore, as there are more and more outages or load shifts in the 11 kV system, voltage regulation and transformer loading will improve. This will have no impact on 66 kV and upstream network.

As a part of the study, more than one 66 kV bay has been considered to build certain scenarios, however, due to space constraints in many 66 /11 kV substations, as many bays may get psychically created only in extreme cases.

## Feasibility of supply to multiple 66 kV consumers through single feeder

### CEA regulations 2010

Clause number 44 (6) of CEA (Measures relating to Safety and Electricity Supply) Regulations, 2010 available at <https://bit.ly/2FNvwwe>, states that – “There shall be no tapping of another transmission line from the main line for 66 kV and above class of lines”

### Discussion with CEA

The significance of this clause was discussed with Mr. A. K. Rajput, Chief Engineer, CEA in order to determine the correct interpretation of the abovementioned clause. It was found that this clause has been inserted due to safety issues – due to high fault current. It was discussed that in case of 66 kV, LILO configuration of breakers may be used by utilities, or in case of direct tapping, appropriate breaker ratings should be used at the feeding substation.

## Short circuit analysis

In order to determine the magnitude of fault currents in the system for various fault scenarios, the above single line diagram has been mapped in ETAP software and short circuit conditions have been simulated. A single line diagram for the proposed arrangement has been shown below –

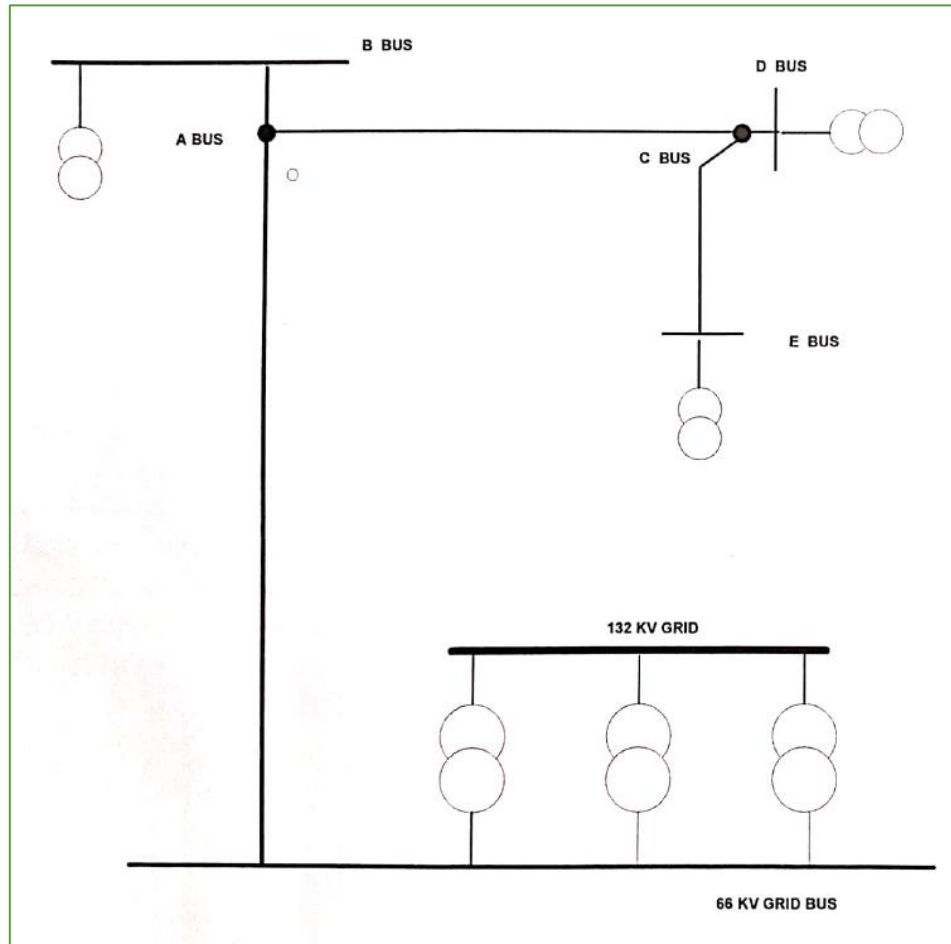


Figure 36 - SLD of proposed 66 kV arrangement

Nominal distance of proposed consumers from 132/66 kV substation taken for this study are as follows:

| From                                        | To                                          | Distance (km) |
|---------------------------------------------|---------------------------------------------|---------------|
| 132 / 66 kV substation                      | 1 <sup>st</sup> consumer connected to Bus B | 2 km          |
| 1 <sup>st</sup> consumer connected to Bus B | 2 <sup>nd</sup> consumer connected to Bus D | 1 km          |
| 2 <sup>nd</sup> consumer connected to Bus D | 3 <sup>rd</sup> consumer connected to Bus E | 2 km          |

Table 147 - Nominal distance of proposed consumers from 132/66 kV substation

### Fault at 66 kV Grid bus

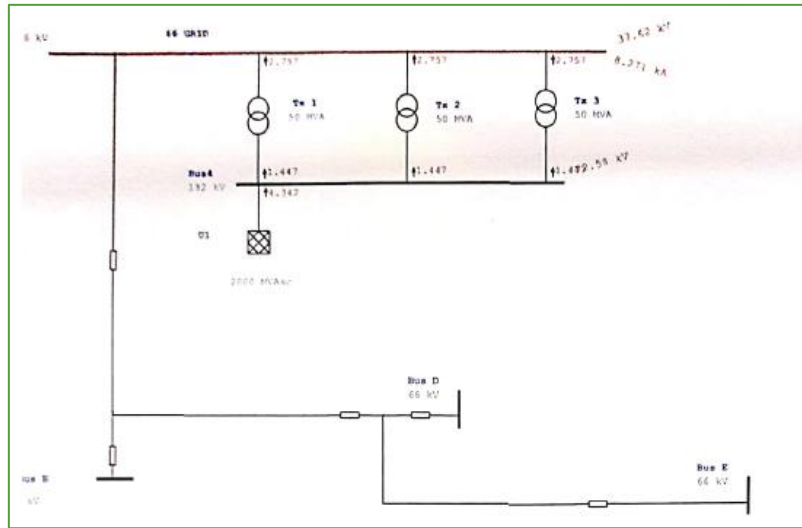


Figure 37 - SLD for SC analysis - fault at 66 kV Grid bus

**SHORT- CIRCUIT REPORT**

Fault at bus: **66 GRID**  
Nominal kV = 66.000  
Voltage c Factor = 1.10 (User-Defined)

| Contribution   |              | 3-Phase Fault   |                 | Line-To-Ground Fault  |       |       |              |       | Positive & Zero Sequence Impedances<br>Looking into "From Bus" |           |           |           |
|----------------|--------------|-----------------|-----------------|-----------------------|-------|-------|--------------|-------|----------------------------------------------------------------|-----------|-----------|-----------|
| From Bus<br>ID | To Bus<br>ID | % V<br>From Bus | kA<br>Symm. rms | % Voltage at From Bus |       |       | kA Symm. rms |       | % Impedance on 100 MVA base                                    |           |           |           |
|                |              |                 |                 | Va                    | Vb    | Vc    | Ia           | 3I0   | R1                                                             | X1        | R0        | X0        |
| 66 GRID        | Total        | 0.00            | 8.068           | 0.00                  | 98.74 | 98.79 | 8.271        | 8.271 | 1.21E+000                                                      | 1.08E+001 | 1.13E+000 | 9.96E+000 |
| TAP A          | 66 GRID      | 0.00            | 0.000           | 0.00                  | 98.74 | 98.79 | 0.000        | 0.000 |                                                                |           |           |           |
| Bus4           | 66 GRID      | 46.83           | 2.689           | 45.61                 | 95.24 | 95.24 | 2.757        | 2.757 | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |
| Bus4           | 66 GRID      | 46.83           | 2.689           | 45.61                 | 95.24 | 95.24 | 2.757        | 2.757 | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |
| Bus4           | 66 GRID      | 46.83           | 2.689           | 45.61                 | 95.24 | 95.24 | 2.757        | 2.757 | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |
| Bus B          | TAP A        | 0.00            | 0.000           | 0.00                  | 98.74 | 98.79 | 0.000        | 0.000 |                                                                |           |           |           |
| TAP C          | TAP A        | 0.00            | 0.000           | 0.00                  | 98.74 | 98.79 | 0.000        | 0.000 |                                                                |           |           |           |
| UI             | Bus4         | 95.24           | 4.235           | 95.24                 | 95.24 | 95.24 | 4.342        | 4.342 | 6.82E-001                                                      | 5.46E+000 | 6.82E-001 | 5.46E+000 |
| Bus D          | TAP C        | 0.00            | 0.000           | 0.00                  | 98.74 | 98.79 | 0.000        | 0.000 |                                                                |           |           |           |
| Bus E          | TAP C        | 0.00            | 0.000           | 0.00                  | 98.74 | 98.79 | 0.000        | 0.000 |                                                                |           |           |           |

Initial Symmetrical Current (kA, rms)

:

3-Phase

8.068

L-G

8.271

L-L

6.987

L-L-G

8.176

Peak Current (kA), Method C

:

19.611

20.105

16.984

19.875

Breaking Current (kA, rms, symm)

:

8.271

6.987

8.176

Steady State Current (kA, rms)

:

8.068

8.271

6.987

8.176

# Indicates a fault current contribution from a three-winding transformer.

\* Indicates a zero sequence fault current contribution (3I0) from a grounded Delta-Y transformer.

Figure 38 - Short circuit results for fault on 66 kV grid bus

The analysis shows that peak current during L-G fault on the 66 kV grid bus is 20.105 kA. Now, since the 66 kV circuit breaker specifications used by GUVNL at 72.5 kV has a breaking current of 31.5 kA,

therefore, we can conclude that the circuit breaker is appropriate for use at 66 kV outgoing feeder from 66 kV grid bus.

### Fault at Bus B

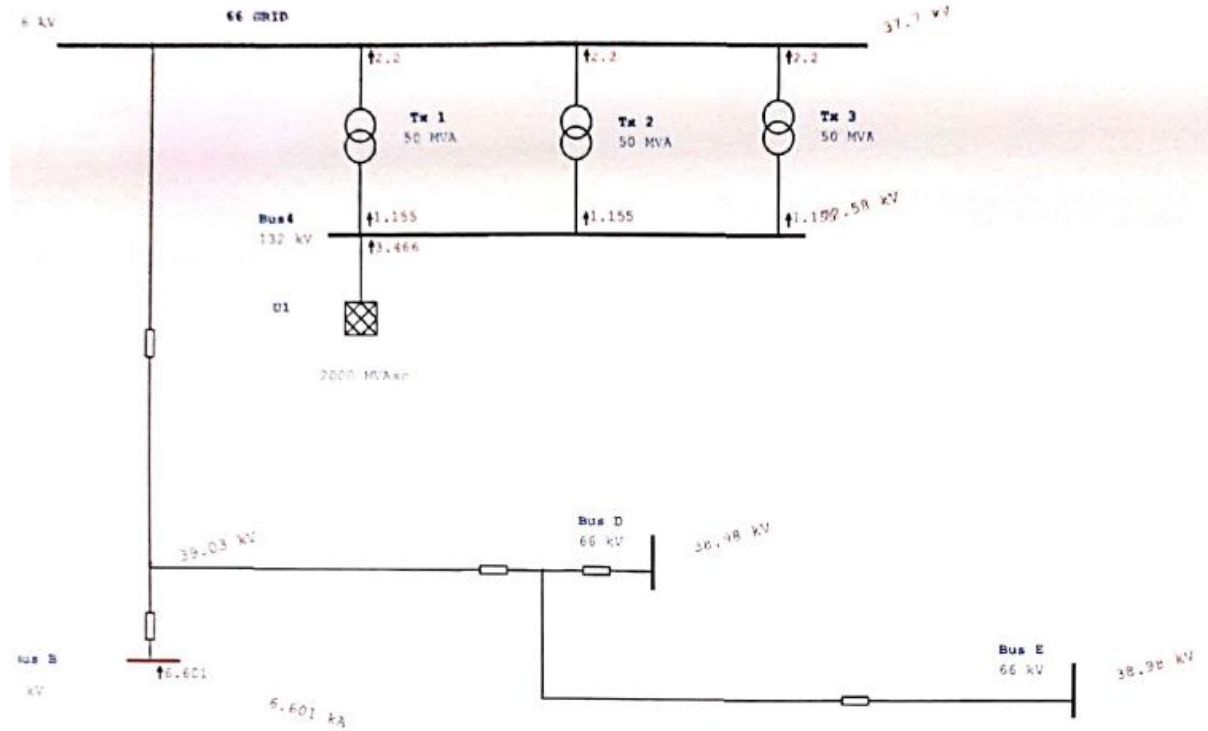


Figure 39 - SLD for SC analysis - fault at Bus B

**SHORT-CIRCUIT REPORT**

Fault at bus

Nominal kV

Voltage c Factor

Bus B

= 66.000

= 1.10 (User-Defined)

| Contribution   |              | 3-Phase Fault |           | Line-To-Ground Fault  |        |        |              |       | Positive & Zero Sequence Impedances<br>Looking into "From Bus" |           |           |           |
|----------------|--------------|---------------|-----------|-----------------------|--------|--------|--------------|-------|----------------------------------------------------------------|-----------|-----------|-----------|
| From Bus<br>ID | To Bus<br>ID | % V           | kA        | % Voltage at From Bus |        |        | kA Symm. rms |       | % Impedance on 100 MVA base                                    |           |           |           |
|                |              | From Bus      | Symm. rms | Va                    | Vb     | Vc     | Ia           | 3I0   | R1                                                             | X1        | R0        | X0        |
| Bus B          | Total        | 0.00          | 7.019     | 0.00                  | 102.43 | 103.82 | 6.601        | 6.601 | 1.59E+000                                                      | 1.23E+001 | 2.26E+000 | 1.47E+001 |
| TAP A          | Bus B        | 0.65          | 7.019     | 0.83                  | 102.31 | 103.68 | 6.601        | 6.601 | 1.59E+000                                                      | 1.23E+001 | 2.26E+000 | 1.47E+001 |
| 66 GRID        | TAP A        | 13.08         | 7.019     | 20.31                 | 98.94  | 99.08  | 6.601        | 6.601 | 1.57E+000                                                      | 1.23E+001 | 2.20E+000 | 1.45E+001 |
| TAP C          | TAP A        | 0.65          | 0.000     | 0.83                  | 102.31 | 103.68 | 0.000        | 0.000 |                                                                |           |           |           |

|                                       | 3-Phase | L-G    | L-L    | L-L-G  |
|---------------------------------------|---------|--------|--------|--------|
| Initial Symmetrical Current (kA, rms) | 7.019   | 6.601  | 6.098  | 6.880  |
| Peak Current (kA), Method C           | 16.739  | 15.743 | 14.542 | 16.407 |
| Breaking Current (kA, rms, symm)      |         | 6.601  | 6.098  | 6.880  |
| Steady State Current (kA, rms)        | 7.019   | 6.601  | 6.098  | 6.880  |

• Indicates a fault current contribution from a three-winding transformer.

• Indicates a zero sequence fault current contribution (3I0) from a grounded Delta-Y transformer.

Figure 40 - Short circuit results for fault at Bus B

## Fault at Bus D

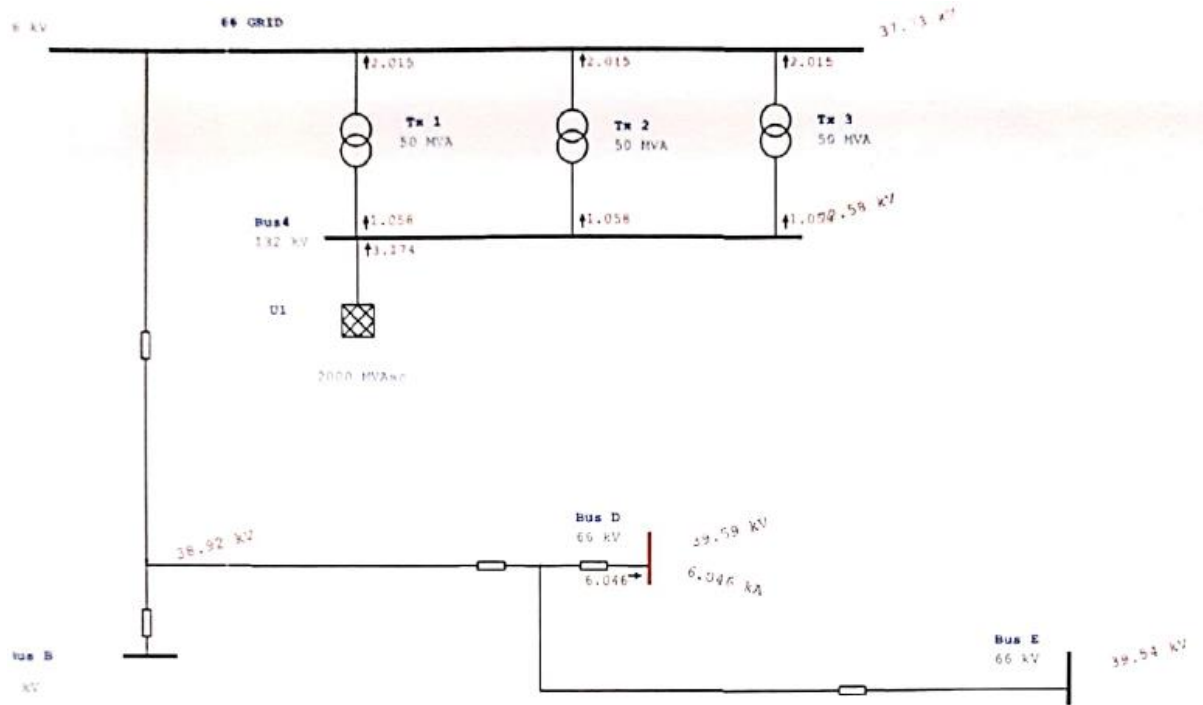


Figure 41 - SLD for SC analysis - fault at Bus D

**SHORT-CIRCUIT REPORT**

| Fault at bus: <b>Bus D</b><br>Nominal kV         = 66.000<br>Voltage c Factor   = 1.10 (User-Defined)                                                                           |              |                 |                 |                       |        |        |              |        |                                                                |           |           |           |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------|-----------------|-----------------------|--------|--------|--------------|--------|----------------------------------------------------------------|-----------|-----------|-----------|--|
| Contribution                                                                                                                                                                    |              | 3-Phase Fault   |                 | Line-To-Ground Fault  |        |        |              |        | Positive & Zero Sequence Impedances<br>Looking into "From Bus" |           |           |           |  |
| From Bus<br>ID                                                                                                                                                                  | To Bus<br>ID | % V<br>From Bus | kA<br>Symm. rms | % Voltage at From Bus |        |        | kA Symm. rms |        | % Impedance on 100 MVA base                                    |           |           |           |  |
|                                                                                                                                                                                 |              |                 |                 | Va                    | Vb     | Vc     | Ia           | I10    | R1                                                             | X1        | R0        | X0        |  |
| Bus D                                                                                                                                                                           | Total        | 0.00            | 6.631           | 0.00                  | 103.89 | 105.55 | 6.046        | 6.046  | 1.75E+000                                                      | 1.30E+001 | 2.76E+000 | 1.68E+001 |  |
| TAP C                                                                                                                                                                           | Bus D        | 0.62            | 6.631           | 0.76                  | 103.76 | 105.41 | 6.046        | 6.046  | 1.75E+000                                                      | 1.30E+001 | 2.76E+000 | 1.68E+001 |  |
| TAP A                                                                                                                                                                           | TAP C        | 6.18            | 6.631           | 9.21                  | 102.14 | 103.33 | 6.046        | 6.046  | 1.74E+000                                                      | 1.30E+001 | 2.71E+000 | 1.66E+001 |  |
| Bus E                                                                                                                                                                           | TAP C        | 0.62            | 0.000           | 0.76                  | 103.76 | 105.41 | 0.000        | 0.000  |                                                                |           |           |           |  |
| 66 GRID                                                                                                                                                                         | TAP A        | 17.92           | 6.631           | 27.05                 | 99.02  | 99.17  | 6.046        | 6.046  | 1.57E+000                                                      | 1.23E+001 | 2.20E+000 | 1.45E+001 |  |
| Bus B                                                                                                                                                                           | TAP A        | 6.18            | 0.000           | 9.21                  | 102.14 | 103.33 | 0.000        | 0.000  |                                                                |           |           |           |  |
| Bus4                                                                                                                                                                            | 66 GRID      | 55.45           | 2.210           | 58.97                 | 95.24  | 95.24  | 2.015        | 2.015  | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |  |
| Bus4                                                                                                                                                                            | 66 GRID      | 55.45           | 2.210           | 58.97                 | 95.24  | 95.24  | 2.015        | 2.015  | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |  |
| Bus4                                                                                                                                                                            | 66 GRID      | 55.45           | 2.210           | 58.97                 | 95.24  | 95.24  | 2.015        | 2.015  | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |  |
| Initial Symmetrical Current (kA, rms)                                                                                                                                           |              | :               | 6.631           | L-G                   |        | L-L    |              | L-L-G  |                                                                |           |           |           |  |
| Peak Current (kA), Method C                                                                                                                                                     |              | :               | 15.703          | 14.318                |        | 13.640 |              | 15.237 |                                                                |           |           |           |  |
| Breaking Current (kA, rms, symm)                                                                                                                                                |              | :               |                 | 6.046                 |        | 5.760  |              | 6.434  |                                                                |           |           |           |  |
| Steady State Current (kA, rms)                                                                                                                                                  |              | :               | 6.631           | 6.046                 |        | 5.760  |              | 6.434  |                                                                |           |           |           |  |
| # Indicates a fault current contribution from a three-winding transformer.<br>* Indicates a zero sequence fault current contribution (I10) from a grounded Delta-Y transformer. |              |                 |                 |                       |        |        |              |        |                                                                |           |           |           |  |

Figure 42 - Short circuit results for fault at Bus D

## Fault at Bus E

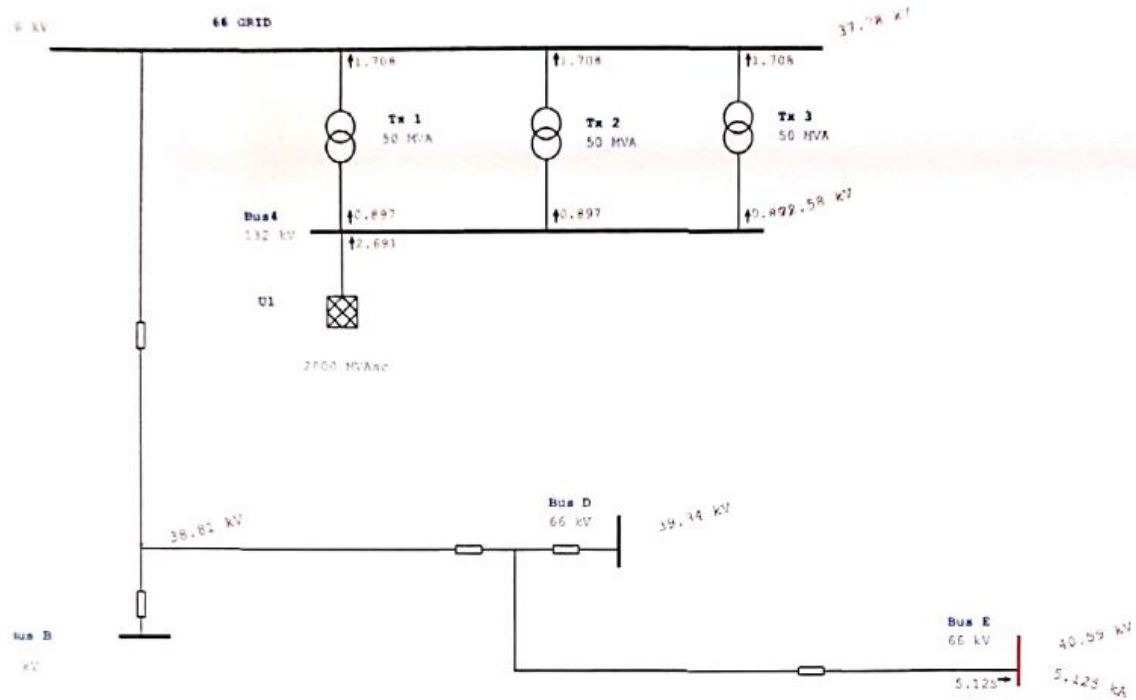


Figure 43 - SLD for SC analysis - fault at Bus E

**SHORT-CIRCUIT REPORT**

Fault at bus: **Bus E**

Nominal kV = **66.000**

Voltage c Factor = **1.10 (User-Defined)**

| Contribution |           | 3-Phase Fault |           | Line-To-Ground Fault  |        |        |              |       | Positive & Zero Sequence Impedances<br>Looking into "From Bus" |           |           |           |
|--------------|-----------|---------------|-----------|-----------------------|--------|--------|--------------|-------|----------------------------------------------------------------|-----------|-----------|-----------|
| From Bus ID  | To Bus ID | % V           | kA        | % Voltage at From Bus |        |        | kA Symm. rms |       | % Impedance on 100 MVA base                                    |           |           |           |
|              |           | From Bus      | Symm. rms | Va                    | Vb     | Vc     | Ia           | I3I0  | R1                                                             | X1        | R0        | X0        |
| Bus E        | Total     | 0.00          | 5.937     | 0.00                  | 106.51 | 108.48 | 5.125        | 5.125 | 2.11E+000                                                      | 1.45E+001 | 3.83E+000 | 2.14E+001 |
| TAP C        | Bus E     | 11.06         | 5.937     | 15.92                 | 103.23 | 104.49 | 5.125        | 5.125 | 2.11E+000                                                      | 1.45E+001 | 3.83E+000 | 2.14E+001 |
| TAP A        | TAP C     | 16.04         | 5.937     | 23.08                 | 101.85 | 102.77 | 5.125        | 5.125 | 1.74E+000                                                      | 1.30E+001 | 2.71E+000 | 1.66E+001 |
| Bus D        | TAP C     | 11.06         | 0.000     | 15.92                 | 103.23 | 104.49 | 0.000        | 0.000 |                                                                |           |           |           |
| 66 GRID      | TAP A     | 26.55         | 5.937     | 38.20                 | 99.15  | 99.31  | 5.125        | 5.125 | 1.57E+000                                                      | 1.23E+001 | 2.20E+000 | 1.45E+001 |
| Bus B        | TAP A     | 16.04         | 0.000     | 23.08                 | 101.85 | 102.77 | 0.000        | 0.000 |                                                                |           |           |           |
| Bus4         | 66 GRID   | 59.62         | 1.979     | 64.50                 | 95.24  | 95.24  | 1.708        | 1.708 | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |
| Bus4         | 66 GRID   | 59.62         | 1.979     | 64.50                 | 95.24  | 95.24  | 1.708        | 1.708 | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |
| Bus4         | 66 GRID   | 59.62         | 1.979     | 64.50                 | 95.24  | 95.24  | 1.708        | 1.708 | 3.63E+000                                                      | 3.23E+001 | 3.40E+000 | 2.99E+001 |

|                                       |         |        |        |        |
|---------------------------------------|---------|--------|--------|--------|
|                                       | 3-Phase | L-G    | L-L    | L-L-G  |
| Initial Symmetrical Current (kA, rms) | 5.937   | 5.125  | 5.142  | 5.665  |
| Peak Current (kA), Method C           | 13.888  | 11.990 | 12.028 | 13.253 |
| Breaking Current (kA, rms, symm)      |         | 5.125  | 5.142  | 5.665  |
| Steady State Current (kA, rms)        | 5.937   | 5.125  | 5.142  | 5.665  |

# Indicates a fault current contribution from a three-winding transformer.

\* Indicates a zero sequence fault current contribution (I3I0) from a grounded Delta-Y transformer.

Figure 44 - Short circuit results for fault at Bus E

## Conclusion from feasibility of supply to multiple 66 kV consumers through single feeder

From the above study, it can be concluded that dedicated 66 kV feeders for single consumers is more suitable as far as guidelines, advantages, losses can dictate. However, there are serious logistical challenges owing to RoW issues. Therefore, the hon'ble commission may choose to allow supply to multiple 66 kV consumers from same feeder in extreme RoW related cases.

### Option 1 – Use of single breaker from 66 kV grid bus outgoing feeder and tapping for multiple consumers on line

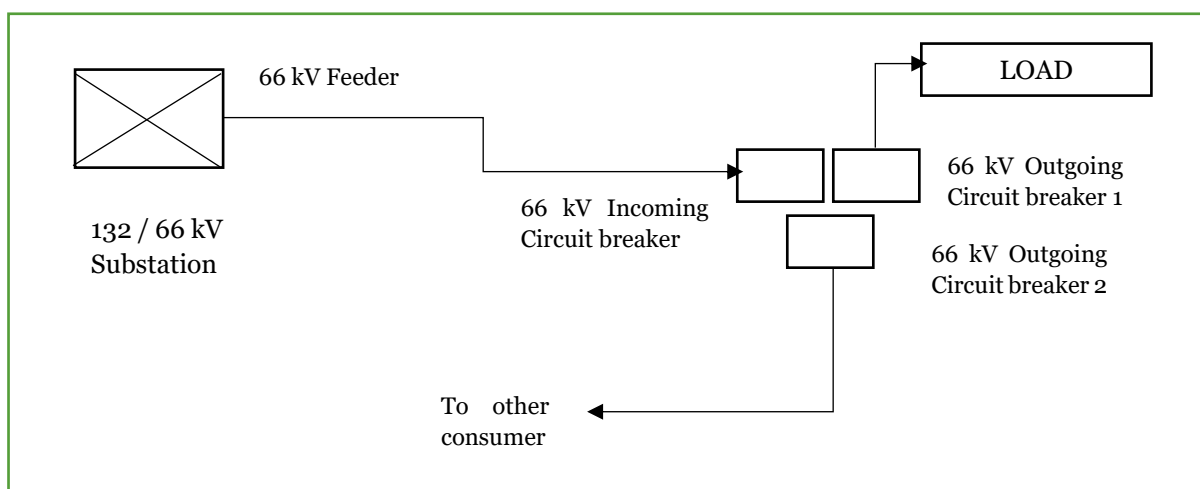
As per results of the above short circuit study, it has been shown that peak fault current is less than breaking capacity of existing 66 kV Circuit breaker at the sending end grid substation. Hence there is no risk of excessive fault current in case of tapping. Also, relay coordination between sending end relay and receiving end consumer relays can be done such that healthy consumer supply is not affected due to fault at another consumer premise connected (tapped) from the same 66 kV feeder. Therefore, hon'ble GERC may allow tapping of 66 kV feeder to cater to supply to other consumers.

### Option 2 – Use of LILO circuit breakers at consumer premises at each node

In such cases, hon'ble commission may mandate a ring main supply with appropriate circuit breaker arrangement at each consumer premise. Also, in such cases, GERC may mandate the requirement of consent from existing consumers before connecting other consumers on the same 66 kV feeder. Use of 66 kV double circuit may be adopted as far as possible. Also, use of Loop-in loop-out incoming and outgoing circuit breakers may be adopted at each consumer substation. A typical configuration of the same is shown below.

### Option 3 – Use of GIS hybrid substation instead of regular circuit breakers at each node

Same as option 2, but may use compact GIS hybrid circuit breakers instead of conventional CBs to save space. These may be pole mounted at the point of delivery to each additional consumer.



## CHAPTER: 13 RECOMMENDATION FROM STUDY

### Consideration for 33 kV supply voltage

As per findings of the study conducted, although conversion of voltage level to 66 kV shall result in reduced loss levels, however the cost of 66 kV conversion is too high to recover within reasonable payback period. However, it may be noted that 33 kV supply is a more viable option for power supply at high voltage for avoiding losses.

33 kV voltage is standard for sub-transmission level in most DISCOMs in India. It has the following advantages –

- Lesser cost footprint than 66 kV for underground cables, transformers, circuit breakers, etc.
- Standard designs for 33/11 kV and 33 / 0.4 kV transformers with more options and configurations of switchgear
- Better voltage regulation and loss vis-à-vis 11 kV level

In most parts of India, 33 kV voltage level is under purview of DISCOMs. In Gujarat, similar stance may be taken so that if introduced, 33 kV level may be handled by DISCOMs.