Distribution Asset Failure and Impact on Consumer Tariff of Jaipur Vidyut Vitran Nigam Limited

Submitted to:

International Copper Association India (Copper Alliance)

By:

Idam Infrastructure Advisory Pvt. Ltd.

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Abbreviations/Acronyms	Expanded Form
A&G	Administration and General
ACoS	Average Cost of Supply
ARR	Annual Revenue Requirement
BG	Beyond Guarantee
DT	Distribution Transformer
GFA	Gross Fixed Asset
JCC	Jaipur City Circle
JVVNL	Jaipur Vidyut Vitran Nigam Limited
JdVVNL	Jodhpur Vidyut Vitran Nigam Limited
KEDL	Kota Electricity Distribution Limited
KPI	Key Performance Indicators
kVA	Kilovolt Ampere
LT	Low Tension
MUs	Million Units
MVA	Megavolt Ampere
P&M	Plant and Machinery
R&M	Repairs and Maintenance
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SoP	Standard of Performance
WG	Within Guarantee

Executive Summary

Efficacy of practices followed for investment in the distribution assets and in their upkeep and maintenance has far reaching implication on the financials of the utility, resulting in tariff of the Consumers. In the present times where many of the public distribution utilities are ailing with high levels of network losses and low supply quality, it is relevant to undertake a review of the investment and management practices of distribution assets. Further, an indication of the extent of its impact on the aggregate revenue requirement of the utility and tariff will enable to quantify and appreciate the need to look critically at this issue. This, in-turn, will enable the utility in taking right kind of steps to plug associated inefficiencies thereby aiding their financial turnaround.

The distribution assets such as distribution transformers (DTs), conductors, LT panels, metering equipment's etc., serves as key element of the power distribution network. Failure of these assets leads to:

- Failure of distribution system.
- Revenue loss due to downtime.
- Financial loss in repair and replacement.
- Failure in meeting reliability indices related to quality supply to consumers.

In this context, the International Copper Association India (ICAI) has commissioned a study to review the utility investments in distribution assets and assess the extent of impact of distribution asset failure on retail tariff of the utility.

The present study is carried out in Jaipur Vidyut Vitran Nigam Limited (JVVNL) Distribution Licensee area. JVVNL is one among the three distribution utilities in the State of Rajasthan. All the required data for the study is obtained from JVVNL and public domain.

From the analysis of various distribution assets relating to the share of each asset in Gross Fixed Assets (GFA) and failure rate, following factors are observed:

- Plant and machinery and lines and cables comprise of a major portion of share in GFA, and capitalisation added during each year in JVVNL.
- Comparing to all other assets, DT failure rate is higher. Simultaneously, DT works as a heart of the distribution system.

Considering the above-mentioned factors, a detailed study of DT failure and its impact on tariff in JVVNL is carried out. DT failure in rural areas of JVVNL is higher than urban areas mainly due to overloading and theft. DT failure has impact on operational expenses as well as capital expenses of utility. Hence, both of these expenses have been studied in detail and impact of DT failure on these expenses is derived in terms of INR Cr and per unit.

The following are the key findings of the study:

- Distribution/Wheeling cost of JVVNL constitute around 28% of the ARR in FY 2019-20 and shows importance and need for optimization.

- Asset related direct cost (depreciation, interest on loan and R&M) is ₹1.48/unit (FY 2019-20).
- Out of total ~7 lakh DT population, ~70,000 DT failure account for ~10% failure rate, which is high. Significant scope for reducing asset failure rate exist in JVVNL.
- DTs failed beyond guarantee (BG) period are the one causing capital cost implications on the utility, out of which ~90% are replaced.
- Absolute impact of DT failure to JVVNL is assessed as ₹176 Cr in FY 2020.
- Financial impact of DT failure as percentage of 'Asset ARR of JVVNL' is assessed as 5% in FY 2020.
- Per unit impact of DT failure is 7 paise out of ₹1.48 of total asset related per unit cost.
- In addition, it is assessed that JVVNL lost revenue of ₹16.80 crores in FY 2020 due to time lost in repair/replacement of the transformer.

This report is structured in the following manner.

Chapter 1: Background, scope of work and limitations of the study.

Chapter 2: Distribution Network Assets and Overview of JVVNL Distribution Network

Chapter 3: Transformer failure analysis and its impact on tariff.

Chapter 4: Review of transformer failure and distribution asset performance.

Chapter 5: Key findings and way forward.

1. Introduction

1.1. Background

Distribution system is the backbone of power sector in India. Although, it is also the weakest link in electricity delivery to citizens and fuelling the Gross Domestic Product (GDP) growth since the financial health of public distribution utilities is reported to be poor. It is facing problems related to high network losses and low supply quality due to several reasons, including underutilization of resources, absence of asset management philosophy, cross-subsidy mechanisms, theft, poor industrial relations etc.

Distribution utilities are facing issues relating to high transformer failure rate in the range of 12% to 17% compared to very low failure rate observed in private utilities like in developed country which is 1% to 2%. High asset failure rate and low quality of supply build sense of mistrust between utility and its customers. Repeated failures and downtime also mean increase in operations and maintenance cost and which, in turn, has perpetual increasing effect on tariff.

The objective of the study was to review the entire process of replacement/repair of assets and its impact on tariff.

1.2. Scope of Work

As per the scope of work, the present report covers the following:

- Review distribution assets and DT failure (only 33 kilovolt [kV] and below system) information over a 3-year period (FY 2017-18 to FY 2019-20) in the selected DISCOM. (No failure analysis or reasons thereof needed as part of this study).
- Collect information relating to past purchases of distribution assets, the key capital asset failures observed, and the replacements undertaken by the DISCOM for each type of capital-intensive assets.
- Examine if these expenses were booked under operational expenses or capital expenses.
- In case of failures, review whether replacements or repairs were carried out during the year and the associated amount spent.
- Review how these costs are reflected in the ARR filed by the utilities annually and if these are being approved by the Regulator.
- Analyse the impact of these costs on tariffs charged to the consumers.

As per the scope of work, JVVNL, one of the utilities in Rajasthan is selected for the study.

1.3. Limitations of the Study

Considering the scope of work and data availability, following were the limitations to carry out the study:

- The study is data intensive and the same was sought from JVVNL.
- While significant data was shared by JVVNL, some data was unavailable.
- Hence, assumptions based on the discussion with JVVNL, and other stakeholders were considered for the study.
- Documents available in public domain such as ARR Petitions filed by JVVNL, ARR Orders issued by RERC for JVVNL etc., were relied upon.

Letter of Consent from the Distribution Company for the Study

A discussion was held with JVVNL regarding the study and the Managing Director (MD) was pleased to issue a letter of consent to carry out this study for JVVNL. The said letter was issued on **July 09, 2020,** with Reference No. **JPD/MD/ACE (MM) /SE (MM-II)/F./D.1574.**

2. Distribution Network Assets and JVVNL Distribution Network

2.1. Typical Distribution Network Assets

Before starting with the analysis conducted for this study, lets first understand, what are the various elements that forms a part of distribution network. A typical distribution network consists of distribution grid substation followed by small pole mounted substations situated in different areas and connected with the distribution grid.

Figure 1: Distribution Grid Substation

A distribution grid substation is connected either with the transmission system carrying power at higher voltage levels (132 kV and above) or connected to another set of distribution grid substation with the same or higher distribution voltage level in the range of 66 kV or 33 kV. These substations are essential to further step down the voltage and distribute through 11 kV feeders, which is then connected to a pole mounted substation.

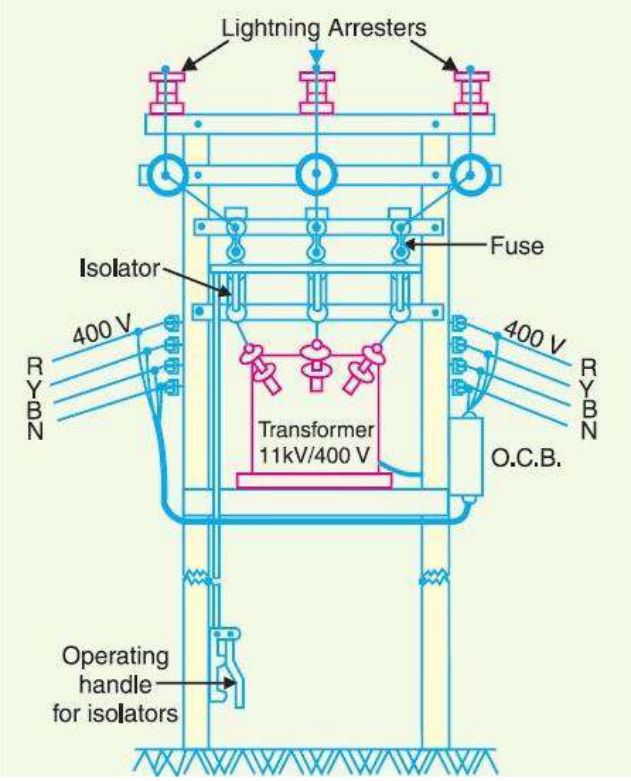


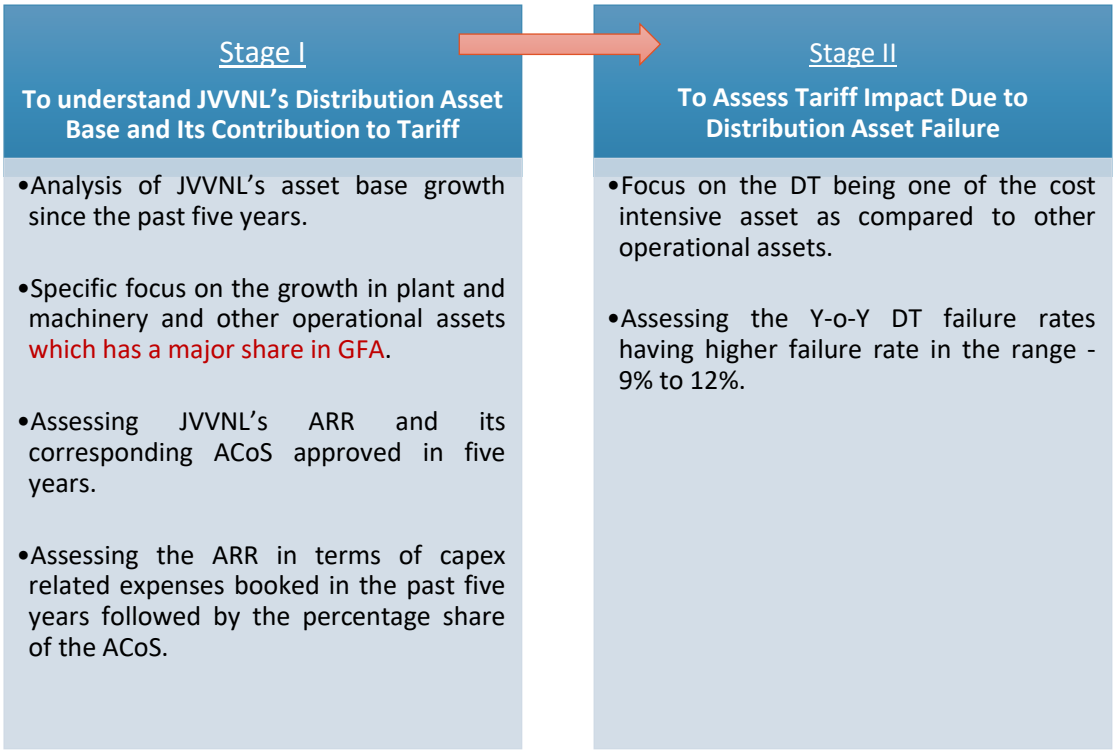
Figure 2: Pole Mounted Substation

A pole mounted substation is located nearby to the consumer area where power is distributed at lower voltages, i.e., at 3 Phase (440 V) or 1 Phase (230 V). These types of substations may have 3 Phase or 1 Phase DTs depending upon the capacity and the type of distribution services to be provided by DISCOM to its various categories of consumers. However, in both, grid and pole mounted substations, the elements are similar, viz. Lighting arrestor, isolator, switchgears/circuit breakers, DTs, bus bars and feeders (in case of grid substation).

Out of these distribution network elements, it is evident that, the most essential and important element is the DT, which is a capital-intensive element. Further, DTs are more prone to failure as compared to other assets of the distribution system. Thus, frequent failures of such capital-intensive assets at distribution level will have significant cost implications on the overall ARR of any utility. With this context, the following chapter will cover JVVNL's specific distribution assets (DT failure particularly) and its overall contribution in consumer tariff.

2.2. Focus of the Study

The focus of the study is to assess the impact of distribution assets failure on tariff. Thus, it is vital to understand JVVNL's distribution asset base and its contribution to tariff to obtain an overall significance of optimisation, Hence, the assessment is carried out via the following two stages.

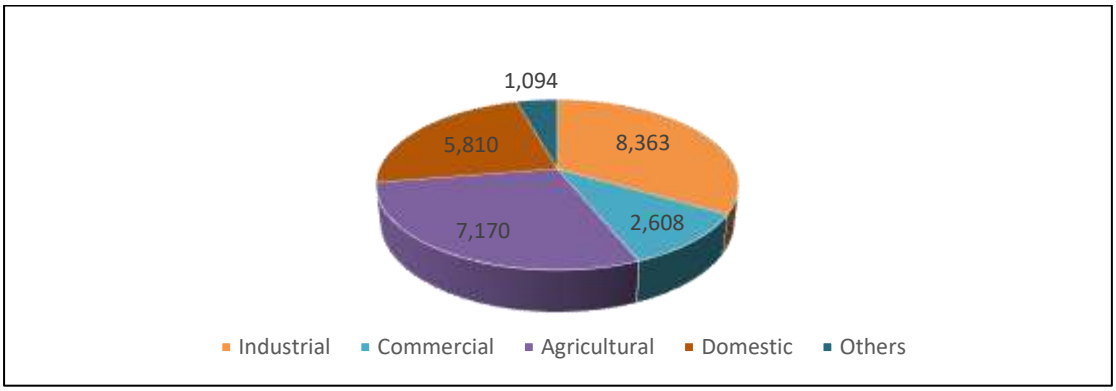


2.3. Overview of JVVNL Distribution Business

JVVNL is engaged in the electricity distribution for 12 districts in Rajasthan namely Jaipur, Dausa, Alwar, Bharatpur, Dholpur, Kota, Bundi, Baran, Jhalawar, Sawaimadhopur, Tonk and Karauli.

The power distribution of the cities of Bharatpur and Kota, which fall under the distribution area of JVVNL, are operated by distribution franchisees. The Kota Electricity Distribution Limited (KEDL), which started its operation in September 2016, and Bharatpur Electricity Services Limited (BESL), which started its operation in December 2016, are wholly owned subsidiaries of CESC Limited.

As per the latest report, the annual energy sales of the company are 25,045 million units (MUs) with annual revenue requirement of 20,174 Cr in FY 2020. Energy sales of JVVNL increased from 19,135 MUs to 25,045 MUs with Compound Annual Growth Rate (CAGR) of ~9% from FY 2017 to FY 2020. JVVNL has served 1.19 Cr of consumers in FY 2020.



Source: JVVNL Tariff Order

Figure 3: Category-wise Energy Sales of JVVNL in MU for FY 2019-20

JVVNL's distribution infrastructure includes 2,49,757 kms of distribution lines at 11 kV, 33 kV, and LT level, along with an aggregate transformer capacity of 29,116 megavolt ampere (MVA) as of March 2020. Of the total distribution line length of JVVNL, 33 kV line constitutes 6%, 11 kV line constitutes 31% and LT lines contribute 63%. In terms of network length, JVVNL holds 33% of the total distribution network in Rajasthan. In terms of transformer capacity, JVVNL holds 37% of the total distribution network in Rajasthan.

Table 1: Network Length of JVVNL and Rajasthan as on March 31, 2020

Voltage Level	Network Statistics (Km) as on March 31, 2020	
	JVVNL	Rajasthan
33 KV	15,932	56,296
11 KV	76,515	2,48,480
LT	1,57,310	4,50,948
Total	**2,49,757**	**7,55,724**

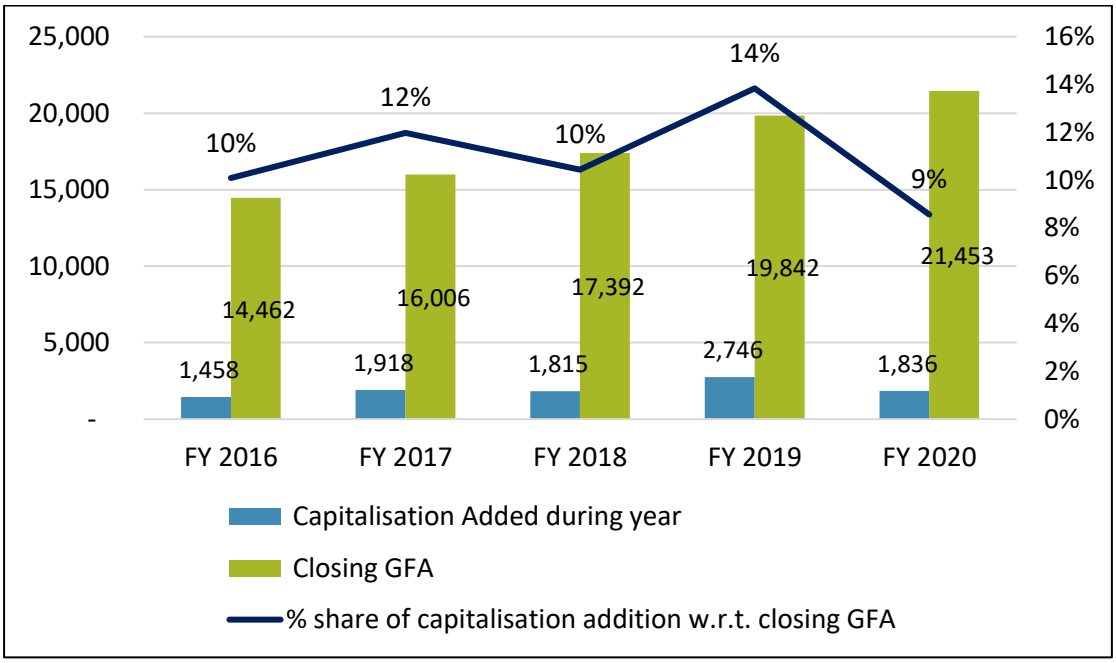
Source: Tariff Petition

Table 2: MVA Capacity of Transformers at JVVNL and Rajasthan as on March 31, 2020

Voltage Level	Network MVA Capacity as on March 31, 2020	
	JVVNL	Rajasthan
33/11 KV	11,786	30,776
11/0.4 KV	17,330	48,403
Total	**29,116**	**79,179**

Source: Tariff Petition

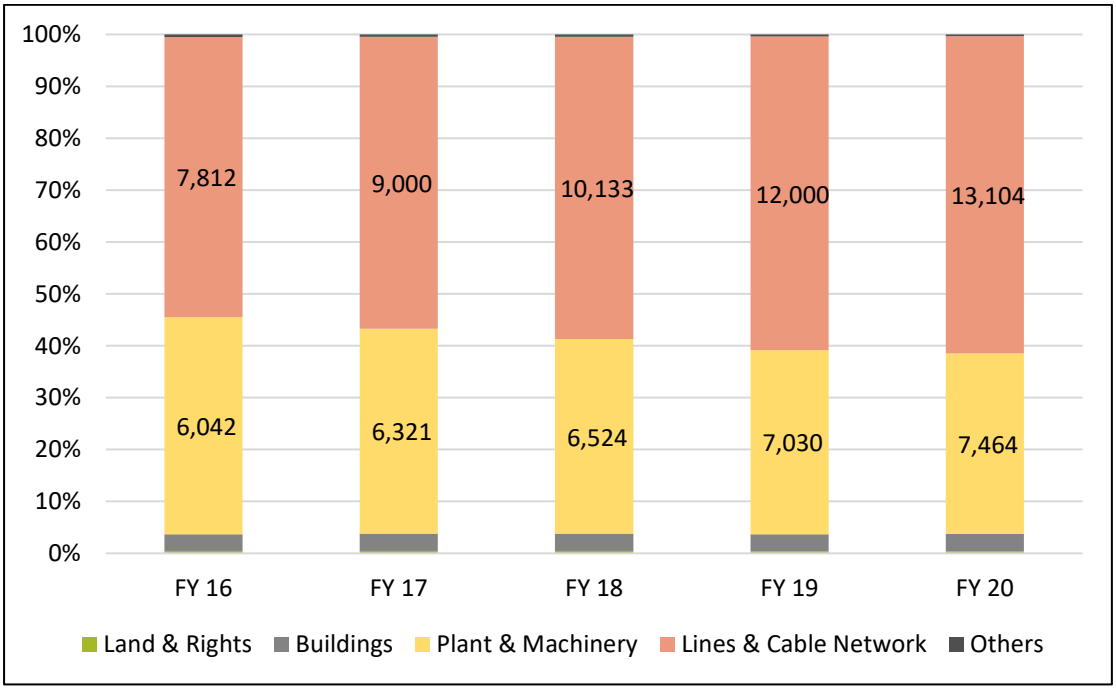
The gross fixed assets of the company for FY 2019-20 are equivalent to INR 21,453 Cr. The GFA of JVVNL is increasing Y-o-Y showing increasing asset base. The annual addition in capitalisation is mostly for plant and machinery (transformer assets) and lines and cables for network expansion as shown in Figure 2.



Source: JVVNL Audited Accounts

Figure 4: Trend of GFA from FY 2016 to FY 2020

In the above Figure, major portion of GFA (around 95% of total GFA) is toward plant and machinery and lines and cables. Plant and machinery mostly covers DT, substation equipment, switchgears, relays, isolators and other protective devices. As the share of plant and machinery and lines and cables are higher in GFA, it has longer implications on tariff.



Source: JVVNL Audited Accounts

Figure 5: Share of Distribution Network Assets in GFA from FY 2016 to FY 2019

The asset base of JVVNL is increasing with significant additional capitalisation in past few years. This indicates that JVNNL is expanding the distribution network with various schemes from the Central Government and State Government such as rural electrification, power for

all, 24/7 power supply. Along with the network expansion, increase in GFA also indicates that asset failure rate is increasing showing an impact on additional capitalisation, addition in Operation & Maintenance (O&M) expenses resulting in increase in consumer tariff.

2.4. Distribution Asset Base and Its Contribution in Consumer Tariff

The data from various Tariff Order is referred and summarised to get the annual expenditures required by JVVNL to serve its consumers. The summary of the ARR for various FYs is provided in Table 3.

Table 3: ARR Parameters of JVVNL

ARR Parameters	Units	FY 2017	FY 2018	FY 2019	FY 2020
Power Purchase Expenses Including Transmission Charges	INR Cr	11,378	12,807	12,423	14,550
O&M Expenses	INR Cr	898	1,065	1,474	1,540
Employee Cost	INR Cr	659	781	1,120	1,202
A&G Expenses	INR Cr	72	87	118	163
R&M Expenses	INR Cr	168	198	236	175
Interest and Finance Charges	INR Cr	1,264	2,296	1,912	2,811
Interest on Working Capital	INR Cr	130	155	140	190
Depreciation	INR Cr	612	619	732	719
Other	INR Cr	824	930	197	364
Total ARR	**INR Cr**	**15,106**	**17,872**	**16,878**	**20,174**
Sales	MU	19,135	19,751	23,476	25,045
ACoS	**INR/kWh**	**7.89**	**9.05**	**7.19**	**8.06**

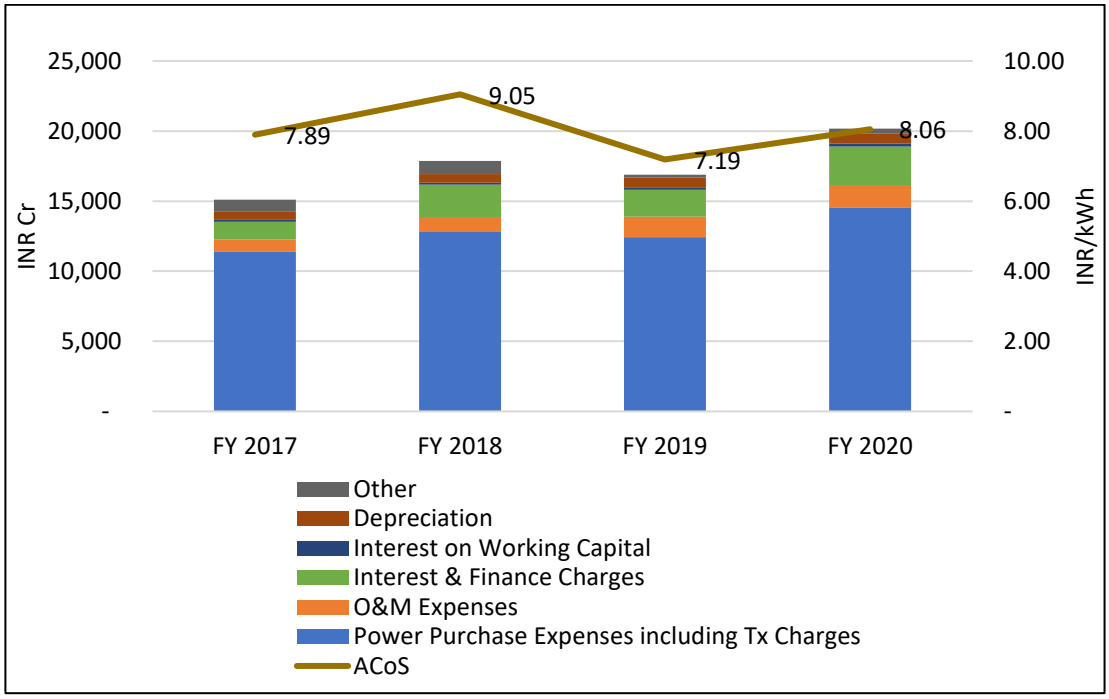


Figure 6: Trend of JVVNL ARR from FY 2017 to FY 2020

It is observed that out of the total ARR, power purchase cost (PPC) constitutes a major share of ~70-75%. Therefore, for specifically assessing the impact of the distribution assets and its cost implication on the utility and tariff per se, the same must be compared with the cost parameters related to assets such as capex and opex (mainly R&M expenses), thereby ignoring the transmission as well as PPC of JVVNL.

With this context, an overall summary of assets related to the direct cost (ARR excluding transmission as well as PPC) for each year is extracted to understand the share of such cost out of the total ARR of JVVNL. The summary of the same is provided in Table 4.

Table 4: Distribution Cost Excluding PPC and Transmission Cost

Distribution Cost	Units	FY 2017	FY 2018	FY 2019	FY 2020
ARR	INR Cr	15,106	17,872	16,878	20,174
PPC and Transmission Cost	INR Cr	11,378	12,807	12,423	14,550
Distribution Cost (ARR Excluding PPC and Transmission Cost)	INR Cr	3,728	5,065	4,455	5,624
Distribution Cost (ARR Excluding PPC and Transmission Cost)	**INR/kWh**	**1.95**	**2.56**	**1.90**	**2.25**
Sales	MU	19,135	19,751	23,476	25,045
Distribution Cost as Percentage of ARR	%	25	28	26	28

Table 5: Asset Related Direct Cost

Asset Related Direct Cost	Units	FY 2017	FY 2018	FY 2019	FY 2020
Depreciation	INR Cr	612	619	732	719
Interest and Finance Charges	INR Cr	1,264	2,296	1,912	2,811
R&M Expenses	INR Cr	168	198	236	175
Total - Asset Related Direct Cost	**INR Cr**	**2,043**	**3,113**	**2,880**	**3,705**
ARR	INR Cr	15,106	17,872	16,878	20,174

Asset Related Direct Cost (Per Unit)	Units	FY 2017	FY 2018	FY 2019	FY 2020
Depreciation	INR/kWh	0.32	0.31	0.31	0.29
Interest and Finance Charges	INR/kWh	0.66	1.16	0.81	1.12
R&M expenses	INR/kWh	0.09	0.10	0.10	0.07
Total - Asset Related Direct Cost	**INR/kWh**	**1.07**	**1.58**	**1.23**	**1.48**
ARR	INR/kWh	7.89	9.05	7.19	8.06

Hence, to calculate the distribution/wheeling cost of JVVNL, PPC and transmission charges are excluded from ARR, which comprises around 1/3rd of the ARR cost. This shows the importance of required optimization. In addition, the asset related direct cost in ARR are Depreciation, Interest and R&M expenses, which is ~ 1.5 INR/kWh. In this context, the subsequent analysis here is focused on the asset related direct cost and its estimated tariff impact to get the actual requirement of optimization, followed by the assessment of potential savings made in the past.

2.5. Specific Directive of Rajasthan Electricity Regulatory Commission (RERC) for Optimising the Capital Expenses of JVVNL

Hon'ble RERC in its Tariff Order of FY 2020 has directed JVVNL to optimise the capital expenses and prepare financial turnaround plan for DISCOM. The following extract of the referred directive is provided as under:

> *"The Commission shows its serious concern towards Discoms state of affairs and directs the Discoms to prepare the following comprehensive action plans for improvement in performance:*
>
> ***(i) Loss Reduction Plan:***
>
> *A loss reduction plan indicating technical as well as administrative measures to be adopted clearly showing the milestones and responsibility at various levels, this plan shall also include plan for metering, billing, collection, segregation of losses and measures to be adopted for control of theft among other measures.*
>
> ***(ii) New developments/Challenges:***
>
> *A medium-term business plan indicating likely impact and strategy to deal with electric vehicles, distributed generation, prosumers and influx of renewable energy and other related trends of power sector.*
>
> ***(iii) Financial Turnaround plan**:*
>
> *A financial turnaround plan which shall contain the road map for financial turnaround showing likely expenses, revenues, availability and requirement of funds, need for tariff increase, plan for optimization of capital and revenue expenses, need for improvement in operational parameters, restructuring of debts and initiative for cash flow improvement."*

Thus, assessing the impact of asset failure and keeping a close check on the same is an important consideration for JVVNL. Hence, in the following chapters, the study becomes more specific to this similar aspect and the estimated impact will highlight the necessity of optimising its cost in terms of failures related to distribution assets, which can be controlled by JVVNL.

Compliance by JVVNL to RERC Directive in the Latest Tariff Filings

JVVNL has filed a tariff petition in RERC for FY 2021, wherein as per the directive given by RERC in the previous order, a financial turnaround plan has been submitted. As per the plan, JVVNL has identified cost components of tariff where savings can be done, which are as follows. The relevant extract of mention with respect to R&M expense is highlighted:

1. *Power Purchase Cost optimisation…*
2. *O&M Expense optimisation…*
    - *Reduction in employee expenses*
    - *Reduction in A&G Expenses*
    - *Reduction in R&M expense:*

    "Since the Discoms manage a huge physical network spanning across the entire state, the repair and maintenance expenses is significant. Through increased private sector participation in the form of Distribution Franchisees, the R&M expense of Discoms can be curbed. The maintenance of assets in the area awarded to DF shall be borne by the DF, thus leading to significant savings for Discoms. At present there are already 4 DFs operating in Rajasthan, in areas of Ajmer, Bikaner, Kota and Bharatpur."
3. *Reduction in interest and finance charges…*

It is worthwhile to note that, while JVVNL has mentioned that there is scope for reduction in R&M expense, but it is not on account of following better asset management practices and reducing asset failure cases, but through outsourcing of the activities. While this might prove good for solving the issue to an extent within a limited area, the same would be inadequate for solving issues across the license area.

3. Transformer Failure Analysis and Its Tariff Impact

This chapter will further assess the impact of DT failure based on the methodology and assumptions derived from the data inputs received from JVVNL, stakeholder consultation and the data available in the public domain.

3.1. Methodology Used for Modelling Tariff Impact

For assessing the tariff impact, the analysis focused on two key parameters, viz.

a. Analysis carried out from FY 2015-16 to FY 2019-20.
b. R&M expenses covering the expenses specific to old DT repairs and refurbishments.
c. Capital cost/capex for replacing the non-repairable DTs.

Based on these parameters, Idam Infra had pursued data information from JVVNL and referred the documents available in public domain. The details of the data received from JVVNL is enclosed as **Annexures**.

Following are the steps and data inputs used for estimating the tariff impact.

Data Used for Modelling:

- Capacity-wise No. of DTs present in JVVNL network from FY 2016 to FY 2020.
- Capacity-wise DT purchase cost in each year from FY 2016 to FY 2020.
- Circle-wise No. of DTs failed within guarantee (WG) period and BG period from FY 2016 to FY 2020.
- R&M expenses specific to DT repairs and refurbishment from FY 2016 to FY 2020.

Steps for Estimating the per Unit (kWh) Tariff Impact

The steps considered to calculate the per unit impact of asset failure is depicted in Figure 7.

- The capital cost towards DT replacement is assessed based on the number of DTs replaced multiplied with the average cost of DT.
- The annual capex impact of the above capital cost is assessed in terms of the corresponding Depreciation and Interest expenses. Return on Equity (ROE) is another component which should be factored in; however, JVVNL does not claim ROE on its investments. Therefore, such component is not considered.
- The annual opex impact towards the DT repaired is obtained in terms of the R&M expenses and considered.
- The total impact due for DT replacement (INR Cr) = Depreciation + Interest on Loan + R&M expenses for DTs.
- The per unit impact is arrived at by dividing the absolute impact with the total sales of JVVNL in the respective year.

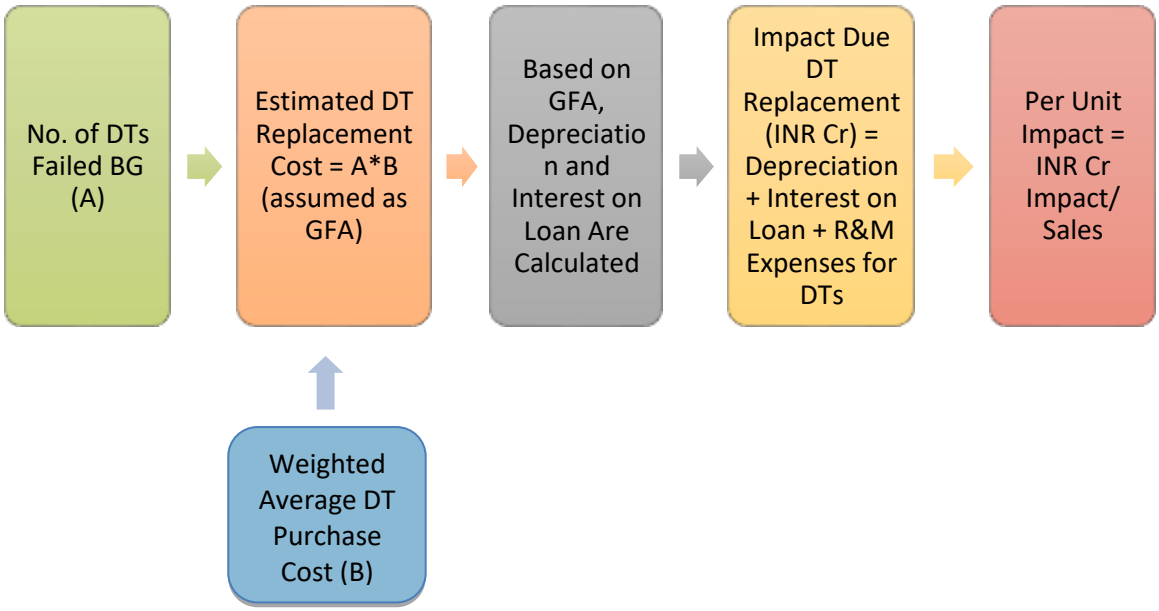


Figure 7: Steps to Estimate the per Unit Impact of Asset Failure on Consumer Tariff

3.2. Key Parameters and Assumption for the Study

Table 6: Data requirement and sources

Key Parameters	Assumptions, If any	Source
Technical Parameters		
Physical Distribution Network Details	-	
DT Failure Details	-	JVVNL's Response to Query
Y-o-Y Number of Installed DTs (1 Phase and 3 Phase, kilovolt ampere [kVA] wise)	-	JVVNL's Response to Query
Reliability Indices and Other Standard of Performance Statistics	-	RERC Website
Financial Parameters		
Y-o-Y Asset Base of JVVNL	-	JVVNL's Audited Accounts
Y-o-Y Capitalisation of JVVNL	-	JVVNL's Audited Accounts
Y-o-Y Sales, Details of ARR and ACoS	-	JVVNL's Tariff Orders for Respective years
Opex - O&M Expenses	-	JVVNL's Audited Accounts
Opex - R&M Expenses in terms of DT Refurbishment	-	JVVNL Response to Query
Capex - DTs Replaced in Respective FY	90% of the Total Failed DTs BG Period	CAG Report, 2019 and Stakeholders Consultations
Capex - Weighted Average Rate of DT per Annum for Each FY	-	JVVNL's Response to Query
Capex - Newly Added DT Cost During the Year	Derived Using Weighted Average Rate for Each Year	JVVNL's Response to Query
Rate of Depreciation and Interest on Loan for Each FY	-	As per RERC Tariff Regulations

Out of the total installed DTs at the JVVNL's network, the data of the DT failures y-o-y is maintained in two categories, viz. WG and BG. The DTs failed in WG have no cost implications since the entire repairs and refurbishment cost is borne by the respective transformer manufacturing companies, while the DTs failed in BG will have an impact in the ARR.

Thus, to estimate the tariff impact, it is important to understand the operational DTs in the entire JVVNL area of supply. The summary of installed DTs in the past five years at different zone and circle is provided in Table 7.

Table 7: Installed DTs in JVVNL Network

Zone	Circle	FY 2015-16		FY 2016-17		FY 2017-18		FY 2018-19		FY 2019-20	
		Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Kota Zone	Baran	36,093	955	38,402	985	38,631	1,359	41,617	1,489	46,002	1,529
	Bundi	27,442	1,022	29,845	1,626	31,954	1,674	37,245	1,704	39,893	1,774
	Jhalawar	39,364	3,679	40,420	3,798	18,208	566	48,014	1,845	50,233	1,866
	Kota	25,322	5,899	27,925	6,412	31,241	1,535	35,772	814	40,592	815
Bharatpur Zone	Bharatpur	36,364	2,476	42,963	2,701	45,000	1,962	51,975	1,602	60,443	1,652
	Dholpur	12,088	1,292	12,189	1,294	15,267	1,384	17,048	1,393	23,205	1,494
	Karoli	32,116	2,081	32,804	2,189	33,154	1,826	35,680	1,061	39,237	2,084
	SWM	28,459	861	30,778	1,071	32,625	1,127	37,807	1,161	40,712	1,218
Jaipur Zone	Alwar	1,17,895	6,294	1,25,734	7,032	1,35,545	7,656	1,43,390	8,158	1,57,907	9,511
	Dausa	43,421	757	44,724	802	46,922	804	54,147	974	58,489	1,080
	JCC	-	12,070	-	12,821	-	13,543	-	13,665	-	14,143
	JPDC	1,42,830	2,884	1,51,894	3,160	1,58,126	3,461	1,47,824	2,732	1,45,203	3,260
	Tonk	18,817	1,698	19,681	1,794	21,709	1,810	26,008	2,425	28,152	2,616
	Sub-total	**5,60,211**	**41,968**	**5,97,359**	**45,685**	**6,08,382**	**38,707**	**6,76,527**	**39,023**	**7,30,068**	**43,042**
	Total	**6,02,179**		**6,43,044**		**6,47,089**		**7,15,550**		**7,73,110**	

**Source: Data Information From JVVNL*

Thus, it is evident from the above summary, JVVNL's major supply of operation is concentrated in the rural Areas as compared to urban Areas, which becomes more interesting while understanding the DT failure rates. The summary of the y-o-y DT failure rates is illustrated in Figure 8.

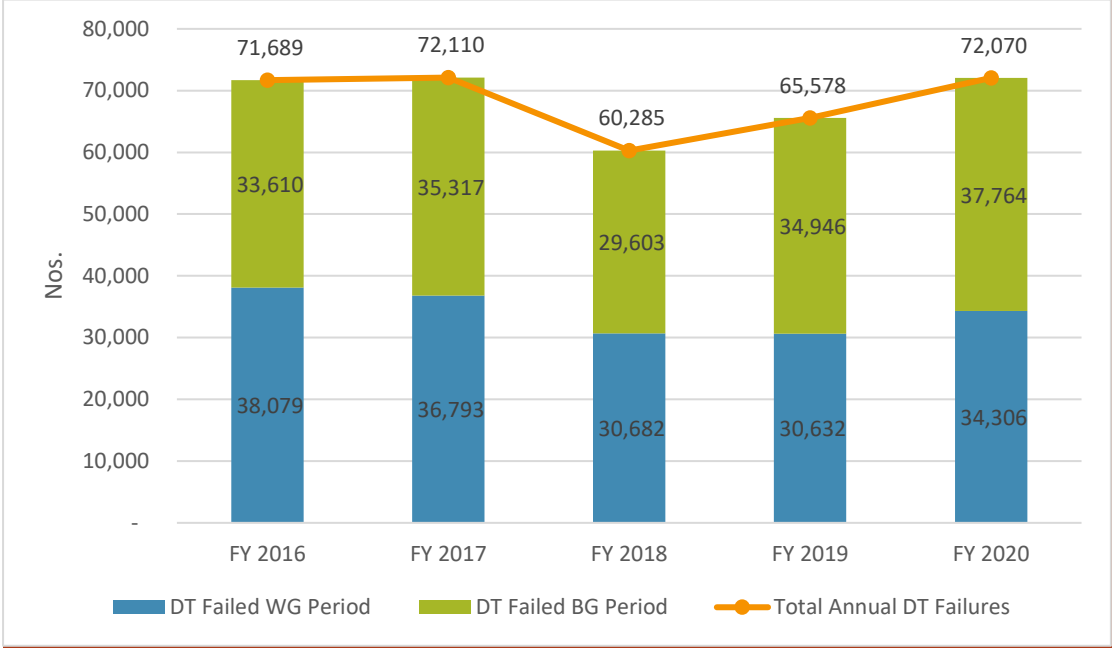


Figure 8: No. of DTs Failed — WG and BG:

The failure rates as compared to the entire year wise DT population falls in the range of 9% to 11%. In addition, the number of DTs failed WG and BG have the ratio of ~50:50. Thus, a major inference from the above summary is that, though the cost implications corresponding to DTs failed WG is zero, but the failure at such a higher level is alarming. In addition, since JVVNL's major services are in the rural areas, the above failures attributed mainly due to overloading of the DTs connected to the rural feeders. In addition, manufacturing defects – poor insulation, loose connection leading to oil leakage, unbalanced load etc., are other major reasons for failures in WG and BG.

3.3. Capital Expense

Those DTs which are failed BG and not in a condition of refurbishment owing to the age factor or higher repair expenses end up in scrap and new DTs are procured under specific capex Scheme, which is duly approved by the State Regulatory Commission in its respective Tariff Order. The expenses related to capex schemes are reflected in the ARR as Interest on Loan, Depreciation and ROE.

While seeking the data from JVVNL specific to the number of DTs being replaced in BG period and its corresponding cost, the same was unavailable since no such type of specific data is being maintained by JVVNL at present. Thus, to estimate the annual cost of DTs procured, which will be replaced with the DTs in scrap, the share of number of DTs being replaced each year is assumed to be 90% out the total DT failed BG for respective year. This assumption Is considered by referring the observations of the CAG in one of its reports released in 2019. The relevant extract of the CAG report is provided as under:

"JVVNL

…….

It would be seen from the above table that during 2015-18, out of 119159 DTs that failed BGP, only 7743 DTs were repaired and 96036 DTs were condemned

and sold as scrap through auction. Further, out of closing balance of BGP failed DTs (15380) as on 31 March 2018, only 238 DTs were to be repaired whereas remaining 15142 DTs had already been condemned and were pending for disposal. ***Thus, out of total of 119159 BGP failed DTs, only 7981 DTs (6. 70 per cent) were repaired/repairable and remaining 111178 DTs (93.30 per cent) were declared condemned and sold/ disposable in scrap.***

…" Emphasis added.

Further, to derive the cost of the DTs replaced, per unit (in INR) weighted average cost per DT is derived based on the year wise DT capacity wise procurement data shared by JVVNL. This derived weighted average cost per DT is then applied on the number of DTs considered to be replaced during the year. The summary of year wise newly replaced DT cost is provided in Table 8.

Table 8: Summary of Year Wise Newly Replaced DT Cost

Particulars	Units	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
DTs Failed	Nos.	71,689	72,110	60,285	65,578	72,070
DTs Failed BG PERIOD	Nos.	33,610	35,317	29,603	34,946	37,764
Failed DTs BG (Replaced)	**Nos.**	**30,249**	**31,785**	**26,643**	**31,451**	**33,988**
DTs Added	Nos.	43,312	45,041	62,192	48,492	49,575
New DTs Replacement Out of the Total DTs Added Above	**Nos.**	**30,249**	**31,785**	**26,643**	**31,451**	**33,988**
Weighted Average Cost of DT	INR	45,770	46,113	46,611	52,043	52,876
Estimated Cost of DTs Replaced	**INR Cr**	**139**	**147**	**124**	**164**	**180**

Further, the above derived capital cost is then used to derive the respective year's Depreciation, Interest on Loan and RoE corresponding to the prevailing MYT Regulations of RERC. In case of JVVNL specific, while referring to various Tariff Order, it was observed that, in none of the Orders, RERC have been claiming RoE for any of the Capital Schemes as most of the funding is either through Debt or by Government Grant or Subsidy programme. Hence, in this context, no RoE impact is derived for the respective year keeping the uniformity with the prevailing mechanism at RERC. Summary of the ARR parameters specific to capex related expenses are shown in Table 9.

Table 9: Summary of the ARR Parameters

Gross Fixed Assets (Amount in INR Cr)					
Particulars	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**
Opening Balance	-	138.45	285.02	409.20	572.89
Addition During the Year	138.45	146.57	124.18	163.68	179.71
Closing Balance	138.45	285.02	409.20	572.89	752.60
Depreciation for Replaced DTs (Amount in INR Cr)					
Accumulated Depreciation Opening	-	7.31	22.36	43.97	74.21
Depreciation for Replaced DTs (Amount in INR Cr)					
Particulars	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**
Addition During the Year	7.31	15.05	21.61	30.25	39.74
Accumulated Depreciation Closing	7.31	22.36	43.97	74.21	113.95
Interest on Normative Loan (Amount in INR Cr)					
Opening Normative Loan	-	131.14	262.66	365.24	498.67
Asset Capitalized During the Year	138.45	146.57	124.18	163.68	179.71
Debt-Equity Ratio	100%	100%	100%	100%	100%
Normative Loan Addition	138.45	146.57	124.18	163.68	179.71
Repayment During the Year	7.31	15.05	21.61	30.25	39.74
Closing of Normative Loan	131.14	262.66	365.24	498.67	638.65
Rate of Interest	11.00%	11.00%	11.00%	11.39%	11.15%
Interest on Normative Loan	**14.42**	**28.88**	**40.16**	**56.80**	**71.19**

3.4. Operational Expense - DT Failure Impact Reflected Under R&M Expenses

The operational expenses majorly comprise of the expenses or the cost attributing to the DT periodic maintenance or the refurbishment of the failed DTs. Thus, out of the failed DTs falling under the BG category may have some chance to get refurbished, which is ~10% of the total DTs failed under BG. Thus, the cost attributing to the DT specific refurbishments or repairs is reported as 15.86 Cr in FY 2018, 31.07 Cr in FY 2019 and 64.92 Cr in FY 2020. The same is compared with other related expenses and summarised in Figure 9.

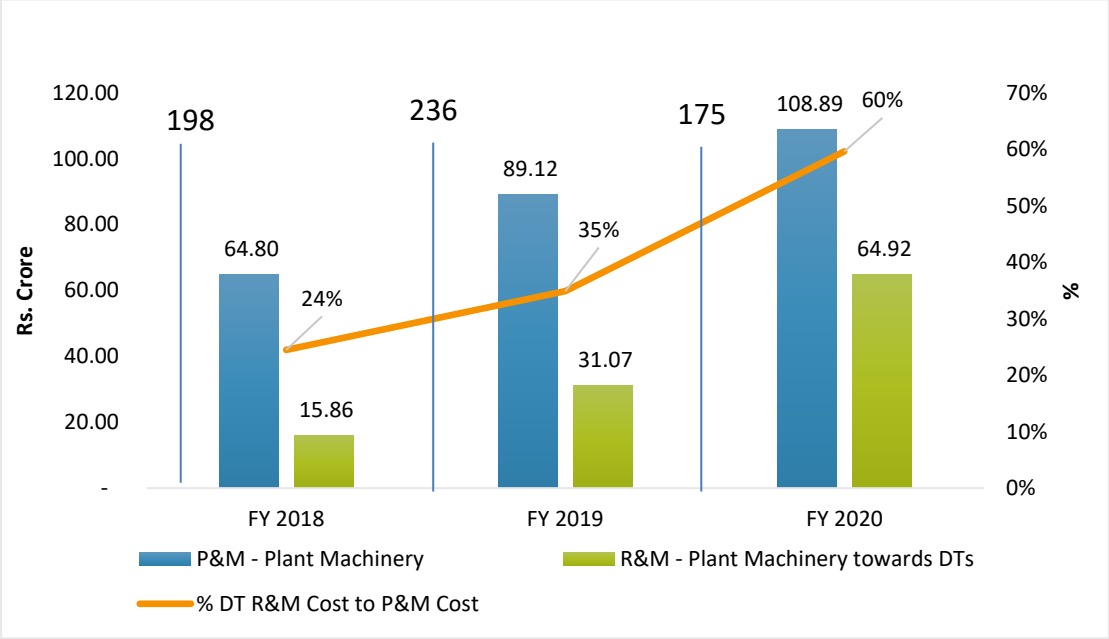


Figure 9: Plant and Machinery Versus DT Repairs and Maintenance Expenses:

**Annual R&M Towards Plant and Machinery Obtained from Audited Accounts.*

***Annual R&M Expenses Towards DT Repair Was Provided by JVVNL as Part of the Information Sought.*

From the above Figure, it is observed that the rate of cost associated regarding the DT refurbishment is doubling every year. The increased number of DT failures does reflect the associated cost of repairs and refurbishment of the DT in large number every year.

3.5. Aggregate Tariff Impact

Table 10: Tariff Impact of DT Failure (INR Cr)

Particulars	FY 2017-18		FY 2018-19		FY 2019-20	
	Overall	DT Failure Impact	Overall	DT Failure Impact	Overall	DT Failure Impact
Power Purchase	**12,807**	**-**	**12,423**	**-**	**14,550**	**-**
O&M Expenses	**1,065**	**16**	**1,092**	**31**	**1,324**	**65**
Employee Cost	*781*	*-*	*1,120*	*-*	*1,202*	*-*
A&G Expenses	*87*	*-*	*118*	*-*	*163*	*-*
R&M Expenses	*198*	*16*	*236*	*31*	*175*	*65*
Less: O&M Capitalised	*-*		*-382*		*-216*	
Depreciation	**619**	**22**	**732**	**30**	**719**	**40**
Interest on Finance Charges	**2,296**	**40**	**587**	**57**	**796**	**71**
ROE	**-**	**-**	**-**	**-**	**-**	**-**
Interest on Working Capital	**155**	**-**	**140**	**-**	**190**	**-**
Other Expenses	**930**	**-**	**1,904**	**-**	**2,595**	**-**
Gross ARR	**17,872**	**78**	**16,878**	**118**	**20,174**	**176**

The depreciation estimated is based on the past period accumulated depreciation. The overall impact in FY 2020 would be on a higher side if the impact is calculated based on the data received for at least 10-15 years. Further, the above estimated impact when compared with the entire ARR in absolute terms appears to be very marginal. However, when the same impact is compared with the asset related cost, the scenario is different. The summary of the tariff impact in absolute terms (INR Cr) as well as the per unit (kWh) is provided in Table 11.

Table 11: Asset related Direct Cost in ARR

Asset Related Direct Cost in ARR	Units	FY 2018	FY 2019	FY 2020
Depreciation	INR Cr	619	732	719
Interest and Finance Charges	INR Cr	2,296	1,912	2,811
R&M Expenses	INR Cr	198	236	175
Total - Asset Related Direct Cost in ARR (A)	**INR Cr**	**3,113**	**2,880**	**3,705**
ARR	INR Cr	17,872	16,878	20,174
Impact of Transformer Failure	**Units**	**FY 2018**	**FY 2019**	**FY 2020**
Depreciation	INR Cr	22	30	40
Interest and Finance Charges	INR Cr	40	57	71
R&M Expenses	INR Cr	16	31	65
Total - Impact of Transformer Failure (B)	**INR Cr**	**78**	**118**	**176**
Impact of Failure as Percentage of Asset Related ARR (B/A)	**%**	**2**	**4**	**5**

Table 12: Tariff Impact of DT Failure (INR/Unit)

Particulars	FY 2017-18		FY 2018-19		FY 2019-20	
	Overall	DT Failure Impact	Overall	DT Failure Impact	Overall	DT Failure Impact
Power Purchase	**6.48**	**-**	**5.29**	**-**	**5.81**	**-**
O&M Expenses	**0.54**	**0.01**	**0.47**	**0.01**	**0.53**	**0.03**
Employee Cost	*0.40*	-	*0.48*	-	*0.48*	-
A&G Expenses	*0.04*	-	*0.05*	-	*0.07*	-
R&M Expenses	*0.10*	*0.01*	*0.10*	*0.01*	*0.07*	*0.03*
Less: O&M Capitalised	-		*-0.16*		*-0.09*	
Depreciation	**0.31**	**0.01**	**0.31**	**0.013**	**0.29**	**0.016**
Interest on Finance Charges	**1.16**	**0.02**	**0.25**	**0.024**	**0.32**	**0.028**
ROE	**-**	**-**	**-**	**-**	**-**	**-**
IoWC	**0.08**	**-**	**0.06**	**-**	**0.08**	**-**
Other Expenses	**0.47**	**-**	**0.81**	**-**	**1.04**	**-**

Particulars	FY 2017-18		FY 2018-19		FY 2019-20	
	Overall	DT Failure Impact	Overall	DT Failure Impact	Overall	DT Failure Impact
Gross ARR	**9.05**	**0.04**	**7.19**	**0.05**	**8.06**	**0.07**

Table 13: Per unit asset related direct cost

JVVNL Sales	**MU**	19,751	23,476	25,045
Asset Related Direct Cost (per Unit)	**Units**	**FY 2018**	**FY 2019**	**FY 2020**
Depreciation	INR/kWh	0.31	0.31	0.29
Interest and Finance Charges	INR/kWh	1.16	0.81	1.12
R&M Expenses	INR/kWh	0.10	0.10	0.07
Total - Asset Related Direct Cost	**INR/kWh**	**1.58**	**1.23**	**1.48**
Impact of Transformer Failure	**Units**	**FY 2018**	**FY 2019**	**FY 2020**
Depreciation	INR/kWh	0.01	0.01	0.02
Interest and Finance Charges	INR/kWh	0.02	0.02	0.03
R&M Expenses	INR/kWh	0.01	0.01	0.03
Total - Impact of Transformer Failure	**INR/kWh**	**0.04**	**0.05**	**0.07**

Thus, the absolute as well as the per unit impact of the transformer failure is INR 176 Cr and INR0.07/kWh in FY 2020, which contributes to ~5% of financial impact and increasing y-o-y. Thus, the impact is significant from the perspective of JVVNL's cost optimisation and financial turnaround plan as directed by RERC in its Tariff Order for FY 2020.

Hence, a potential savings in terms of Debt and RoE is estimated, to understand the level of savings made if these failure rates were controlled by JVVNL. The summary of the same is provided in Table 14.

Table 14: Potential savings in RoE and Debt

Particulars	Unit	FY 2018	FY 2019	FY 2020	Total
Estimated Annual Financial Impact of DT Failure	INR Cr	124.18	163.68	179.71	**467.57**
DT Failure Rate	%	9.32	9.16	9.32	
Acceptable Failure Rate p.a.*	%	2	2	2	
Estimated Capex Acceptable for Replacing DTs	**INR Cr**	**26.66**	**35.72**	**38.56**	100.94
Estimated Total Savings in Capex	**INR Cr**	**97.52**	**127.96**	**141.16**	366.64
Estimated Savings in Loan or Debt	**INR Cr**	**68.27**	**89.57**	**98.81**	256.65
Estimated RoE Savings @30% of Savings in Capex	**INR Cr**	**29.26**	**38.39**	**42.35**	**109.99**

**Note: DT failure rate in India and developed countries are referred from https://www.ijert.org/transformer-failure-analysis reasons-and-methods.*

Thus, savings in terms of avoided capex due to the DT failure can result in reducing the potential debt burden on JVVNL – as reduced debt need to be raised in future. At present, JVVNL does not claim ROE. However, in a scenario where ROE must be deployed for such

capex, ROE required to be deployed can be reduced, resulting in potential savings for JVVNL. Further, the savings would be more significant if the same is estimated for the past 10-15 years.

3.6. Key Inferences of Tariff Impact Analysis

Based on the analysis carried out in this section, the following the inferences:

- Absolute impact of transformer failure to JVVNL is INR 176 Cr in FY 2020.
- Financial impact of transformer failure as percentage of asset related ARR is 5% in FY 2020.
- Financial impact is increasing year on year and must be urgently inspected.
- Per unit asset related direct cost for JVVNL is INR 1.48/unit.
- Per unit impact of transformer failure is 7 paise out of INR 1.48 of the total asset related per unit cost.
- **Impact is significant from JVVNL's cost optimization perspective and financial turnaround plan as directed by RERC in Tariff Order for FY 2020.**

4. Review of Transformer Failure and Distribution Asset Performance

Distribution asset performance is an important aspect to be studied to understand the operating status of assets and its impact on consumers and distribution system. To carry out the detailed study, various type of data is studied and analysed.

JVVNL has shared its yearly data on circle-wise DT failure. The data consisted of following details:

1. Population of DTs in JVVNL network.
2. DTs failed in WG period and BG period from FY 2016 to FY 2020.
3. DT failure statistics of 1 Phase and 3 Phase.
4. DT failure complaints by consumers.
5. Circle wise reliability indices of JVVNL and downtime.

Based on the availability of the above-mentioned data, analysis has been carried out to assess the DT failure rate, trend of DT failure rate from FY 2016 to FY 2020, circle-wise performance of distribution assets and downtime in JVVNL area.

4.1. Transformer Failure Rate – Urban Versus Rural

JVVNL has 7,73,110 DTs operating in distribution network in FY 2020 with major number of DTs operating in rural circles.

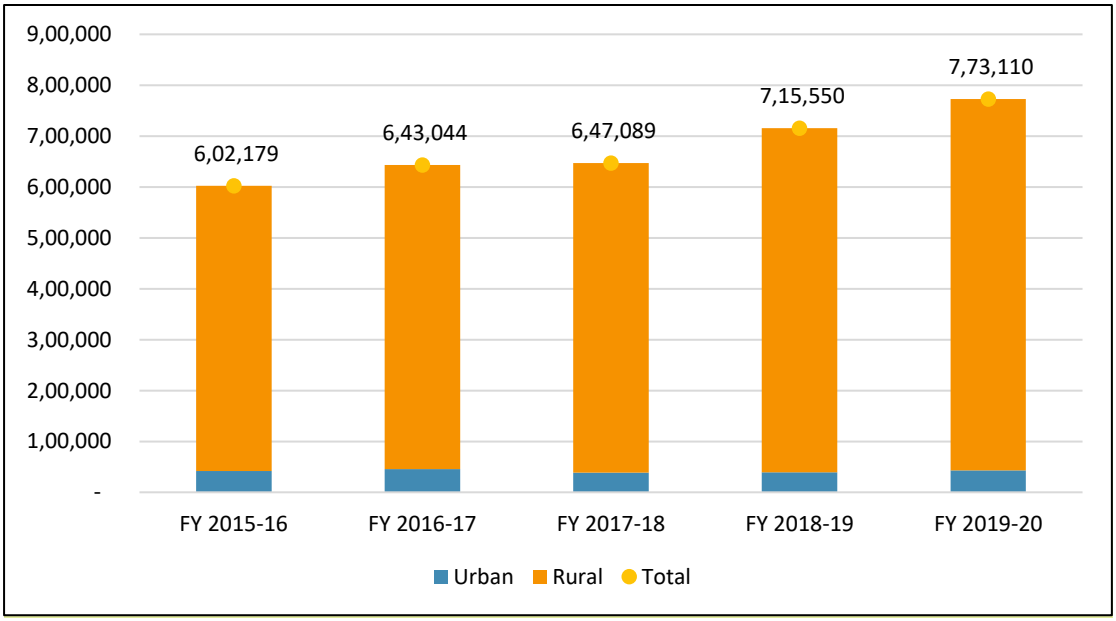


Figure 10: Population of DTs in Rural and Urban Circles of JVVNL [1]

DT failure rate is basically the no. of DTs failed annually with respect to the total no. of DTs in operation in distribution network.

[1] *Data shared by JVVNL.*

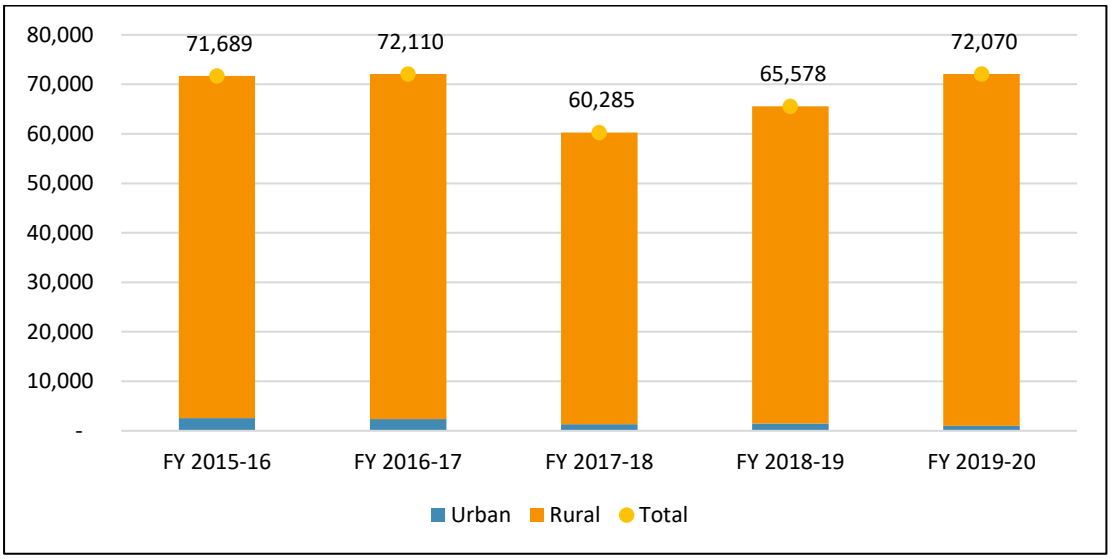


Figure 11: No. of DTs Failed in Rural and Urban Circles[2]

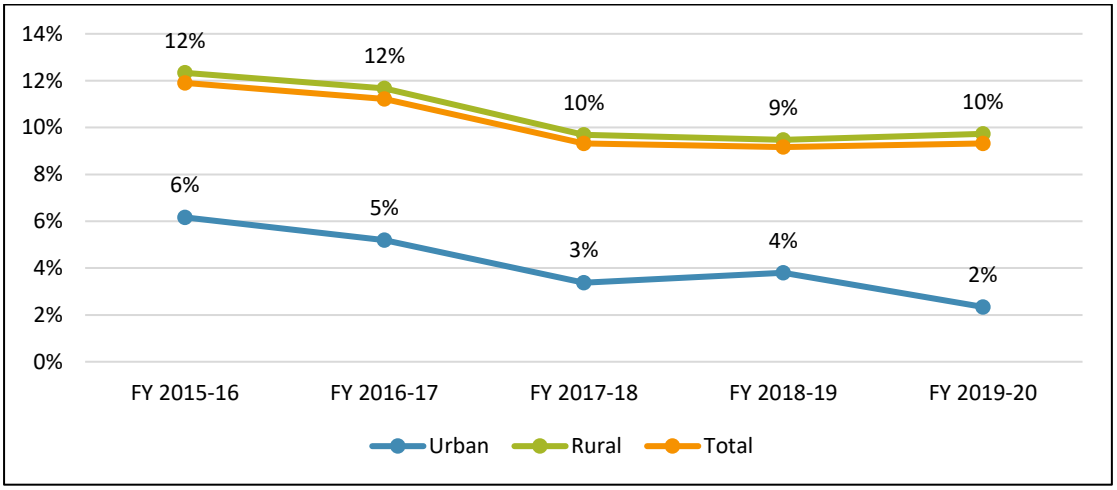


Figure 12: Trend of DT Failure Rate in Rural and Urban Circles

DT failure rate is observed to be higher in rural areas as compared to the urban areas. The failure rate in urban areas ranges from 2-6% whereas the failure rate in rural areas ranges from 9-12% with respect to the population of DTs in urban and rural circles. Though, the failure rates were reduced in initial years, there is no significant improvement in recent years. One of the important causes of higher DT failure rate in rural circles is overloading of DTs.

It is observed that, DT failure in Alwar, JPDC is significantly higher than other circles. Alwar and JPDC circle mainly covers rural areas of JVVNL.

[2] *Data shared by JVVNL.*

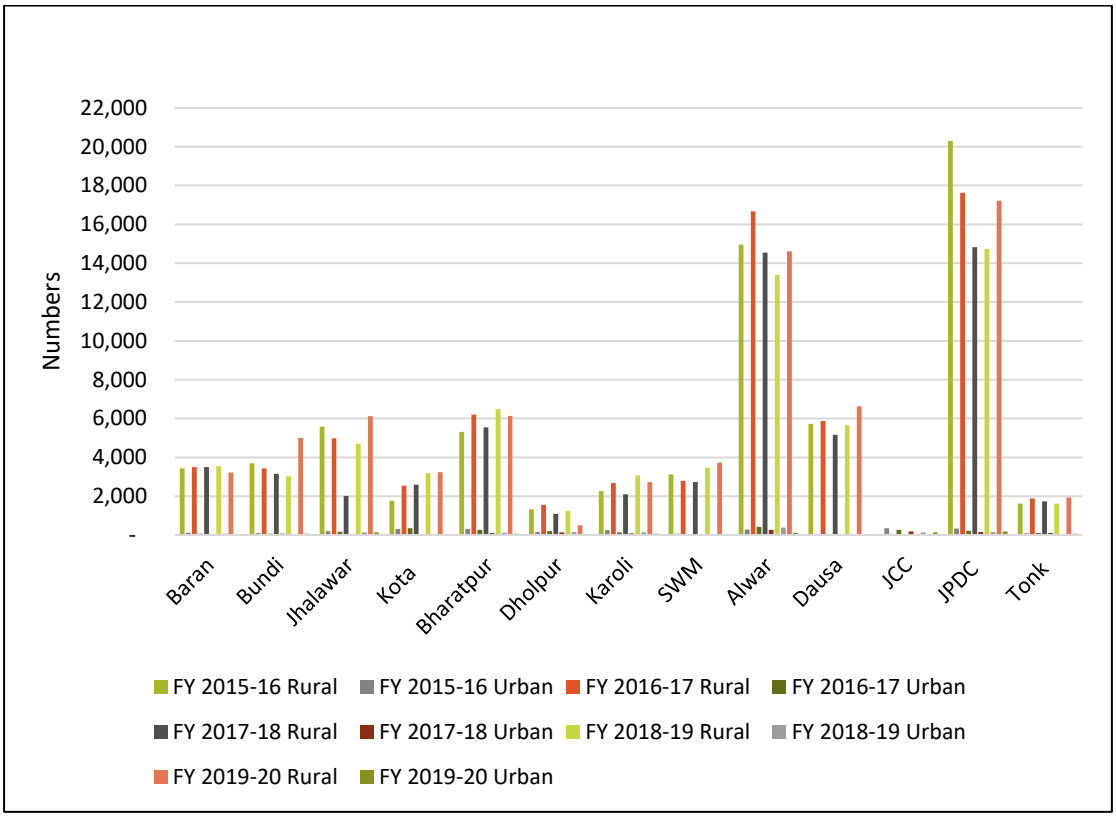


Figure 13: Circle Wise Trend of DT failure – WG +BG

4.2. Transformer Failure Rate – 1 Phase Versus 3 Phase

The overall population of DTs in JVVNL is increasing annually with network expansion. Number of 3 phase DTs in JVVNL is significantly higher as compared to 1 phase DTs. However, DT failure rate of 1 phase is higher than 3 phase DTs. This is due to the fact that DT failure rate in rural circles is higher and higher number of 1 phase DTs are present in rural circles.

Table 15: Population of DTs in JVVNL Network[3]

Particulars	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020
3 Phase	4,51,102	4,73,622	4,66,715	5,09,713	5,52,739
1 Phase	1,51,077	1,69,422	1,80,374	2,05,837	2,20,371
Total	6,02,179	6,43,044	6,47,089	7,15,550	7,73,110

Although, the failure rate of DTs is reducing, it has not reduced significantly over the period.

[3] *Data shared by JVVNL.*

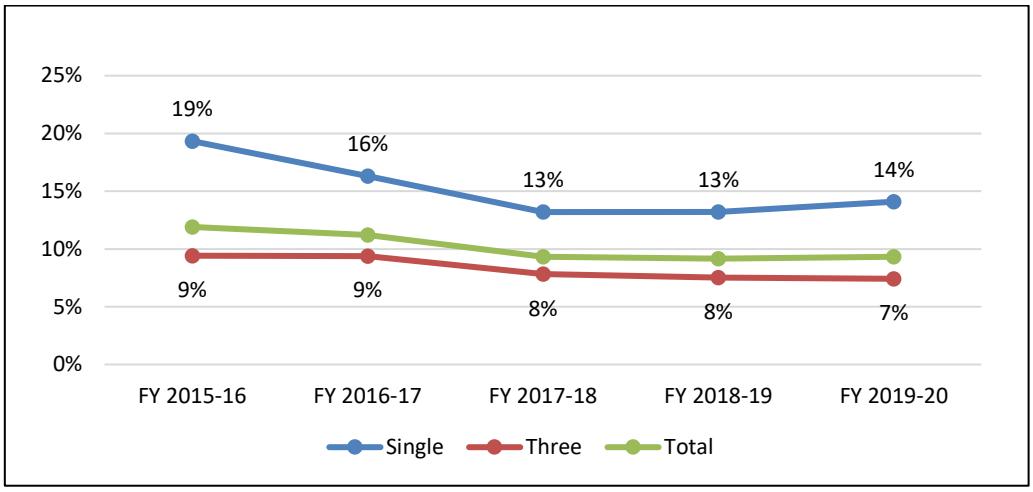


Figure 14: 1 Phase Versus 3 Phase Rate of DT Failures in JVVNL

4.3. SOP Compliance w.r.t Transformer Failure – Need for Regulation Amendment

JVVNL publishes Standard of performance (SoP) reports on quarterly and half yearly basis. SoP reports has significant information about the consumer complaints relating to SoP parameters such as defective meters, DT failure, power outage, overhead line/cable breakdown, underground cable breakdown, meter replacement, voltage variation, scheduled outage etc.

Accordingly, DT failure complaints received in JVVNL from FY 2016 to FY 2020 are given in Table 16.

Table 16: Statistics of DT Failure Complaints and DT Operational Status Target[4]

FY	Half Yearly Period	No. of DT Failure Complaints	Transformers in Working Condition/ Total No. of DTs Connected in Service (%)	Target as per SoP (%)
FY 2016	H1	15,866	92.27	90
	H2	17,848	99.41	
FY 2018	H1	17,197	99.96	
	H2	16,076	99.61	
FY 2019	H1	24,650	99.93	
	H2	23,456	99.87	
FY 2020	H1	22,796	98.25	
	H2	28,075	98.61	

From the above statistics, it is observed that JVVNL maintains the target of DT operational services at ~99% which is well beyond the present target of 90% as per RERC SoP

[4] *JVVNL SoP reports from FY 2016 to FY 2020*

Regulations. This is despite the fact that the failure rate of DTs as observed in the above sections have remained significantly higher. This indicates a disconnect between the present level of norms specified for 'Transformers in Working Condition / Total No. of DTs connected in service' and the actual performance on the utility. It is desired that RERC may review this norm and revise the applicable norms of this parameter through appropriate amendments.

4.4. Reliability Indices and Downtime

A power supply outage is an unplanned event and can be described in terms of the frequency, duration and amount of load (or consumers) affected. A momentary outage is defined as an outage lasting for less than five minutes, corresponding to the time taken by automatic re-closure schemes to restore temporary faults; a sustained outage lasts longer than five minutes (NERC 1996). IEEE standard 1366 provides the definition for outage indices. System Average Interruption Frequency Index (SAIFI) is calculated as the total number of sustained interruptions per consumer and System Average Interruption Duration Index (SAIDI) is calculated as time duration of sustained interruptions per consumer.

SAIFI and SAIDI are the most used pair of reliability indices. SAIFI and SAIDI of JVVNL were around 0.312 and 0.604 in FY 2019.

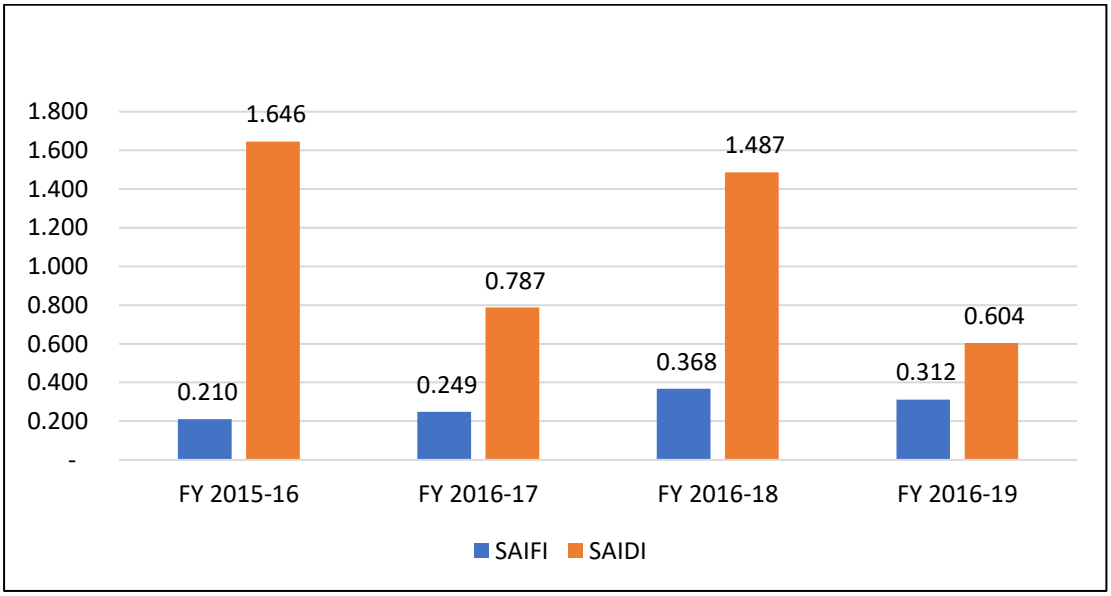


Figure 15: Reliability Indices of JVVNL[5]

Along with the reliability indices of JVVNL and circle-wise reliability index were also reviewed to analyse the interruptions on circle level. Reliability indices of Bharatpur, Sawai Modhopur and Dholpur circles were significantly higher in comparison to other circles indicating higher system interruption.

[5] *JVVNL SoP reports from FY 2016 to FY 2020*

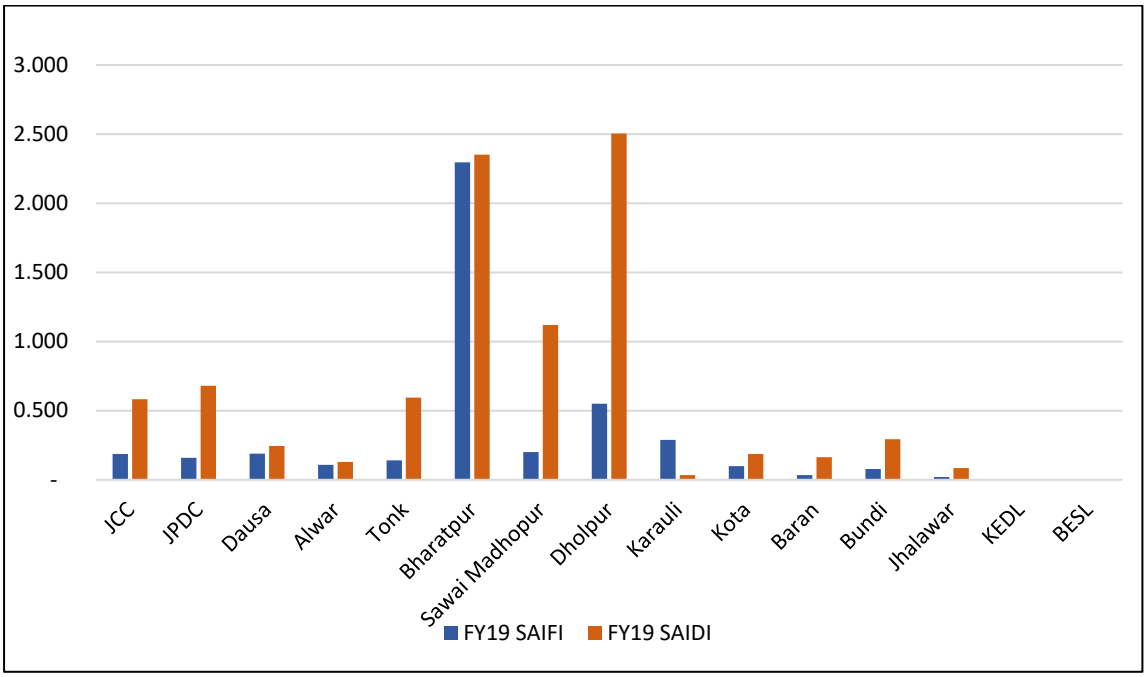


Figure 16: JVVNL Circle Wise Reliability Indices of FY 2019[6]

From the data of SAIDI, sustained duration of interruption was taken for analysis to observe the downtime in JVVNL. From the data of sustained duration of interruptions to consumer, it is observed that, downtime in JVVNL area has reduced significantly from 1,10,911 hours in FY16 to 74,543 hours in FY20. This indicates that power outage events are reduced.

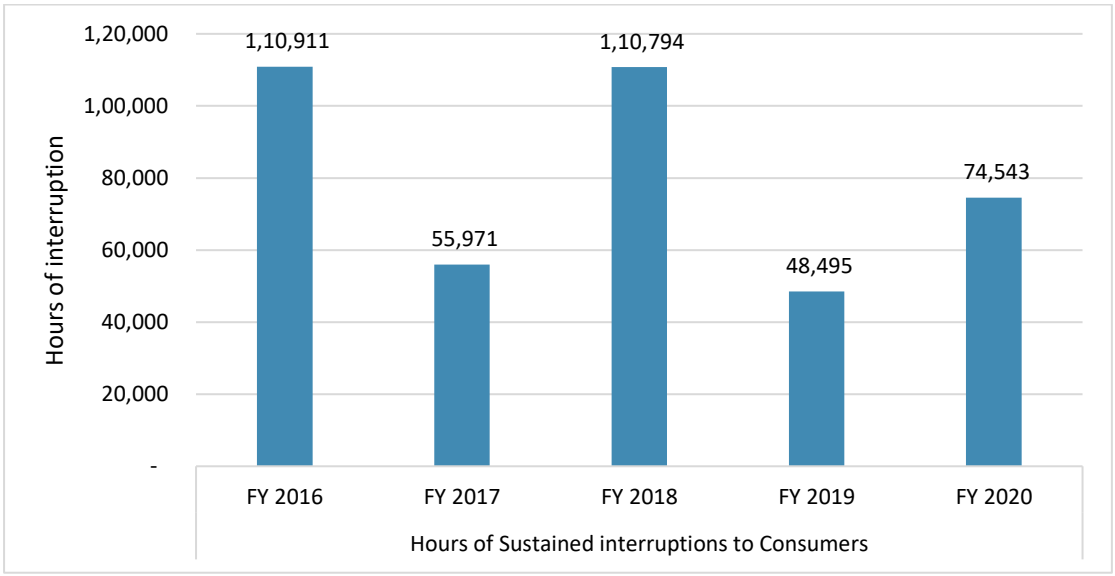


Figure 17: Annual Downtime Recorded in JVVNL Area from FY 2016 to FY 2020

[6] *JVVNL Standard of Performance reports*

From the analysis of above parameters, some major observations are as below:

1. *DT failure rate in rural area is significantly higher.*
2. *JVVNL has performed proper compliance of SoP report. However, increasing trend of the number of DT failure complaints from FY 2016 to FY 2020 can be reduced to avoid additional expenses towards R&M cost.*
3. *Higher DT failure rate increases downtime resulting in revenue loss for utility.*
4. *Increase in DT failure rate shows impact on increase in O&M cost.*
5. *DT failure ultimately increases the expenses of utility which can be avoided with proper maintenance and continuous monitoring of the system.*

5. Key Findings and Way Forward

5.1. Key Findings

Out of the distribution network elements, the most critical element is the D,T which is a capital-intensive element. Further, DTs are more prone to failure as compared to other assets of the distribution system. Basis this, in the present study on distribution asset failure and impact on tariff, a detailed analysis of DT failure rate, causes of failure, practices followed by DISCOM for repairs and maintenance of failed DTs and its commercial impact on tariff has been carried out. From the study, it is observed that distribution asset failure has significant financial impact as well as operational impact on the utility.

Absolute impact of transformer failure on JVVNL is INR 176 Cr in FY 2020. The impact on tariff due to DT failure has increased from INR 78 Cr in FY 2017 to INR 176 Cr in FY 2020 which is twice in the span of three years.

The per unit asset related direct cost for JVVNL is INR 1.48 paise/unit. The per unit impact of transformer failure is INR 7 paise out of INR 1.48 paise of the total asset related per unit cost. This impact is significant from JVVNL's cost optimization point of view and financial turnaround plan as directed by RERC in Tariff Order for FY 2020.

The financial impact of transformer failure as a percentage of asset related ARR has increased from 2% in FY 2017 to 5% in FY 2020.

Out of the total 7 Lakh DTs, over 70,000 failed in FY 2020. This accounts for 10% failure rate which is high. DTs failed beyond guarantee period are the ones causing cost implications on the utility as more than 90% DTs are replaced.

5.2. Way Forward

Recommendations to the Utility

Significant scope of improvement and potential of minimising expenses exists for JVVNL. Reduction in transformer failure in JVVNL area can help in the optimization of capex and opex. Further, reduction in asset failure is important to reduce the overall downtime of interruption for improving quality distribution supply service.

- **Benefit for the Utility:** Avoiding DT failures can potentially benefit JVVNL on multiple counts as listed below:
  - Potential for reducing GFA addition (around INR 120 Cr Y-o-Y).
  - Potential for reducing expenses (around INR 170 Cr Y-o-Y).
  - Comply regulatory directives issued by RERC from time to time.
  - Improve reliability of distribution system and provide better services to the consumers.
- **Key Action Points for the Utility:**
  - Quantify the impact of asset failure on ARR of DISCOMs, in terms of all types of assets and conduct periodic monitoring and review.

- May set up Committee to investigate primary reasons for high failure rate of failure of DTs and strengthen asset management practices covering the areas ranging from vendor selection, procurement, inventory management, scrap disposal etc.
- Initiate study for strengthening R&M practices to ensure timely repair and upkeep of distribution assets. Online DT monitoring system can be installed to monitor the performance of DTs and to initiate timely preventive maintenance.

Regulatory Recommendations

Recommendations considering regulatory perspective are as below:

- Impact of DT asset failure is significant from the perspective of JVVNL's cost optimization strategy. Due to non-availability of data, assessment of impact of failure of other asset classes cannot be performed. Hence, RERC may consider directing all distribution companies to maintain asset class wise failure data.
- The Commission may insist DISCOMs to quantify the impact of asset failure.
- The Commission may direct utilities to factor in savings due to maintaining failure rates at benchmarks set by the Commission.
- Strengthening asset management and R&M practices shall lead to better performance of the utility. This will ultimately result in strict compliance of SOP standards set for the utility.
- Regulator may consider revising the norms to encourage efficiency of the utility and the consumer will be the ultimate beneficiary.

Annexures

1. Extract of CAG Report on Statistics of DTs Scrapped

It would be seen from the above table that during 2015-18, out of 119159[39] DTs that failed BGP, only 7743 DTs were repaired and 96036 DTs were condemned and sold as scrap through auction. Further, out of closing balance of BGP failed DTs (15380) as on 31 March 2018, only 238 DTs were to be repaired whereas remaining 15142 DTs had already been condemned and were pending for disposal. Thus, out of total of 119159 BGP failed DTs, only 7981[40] DTs (6.70 *per cent*) were repaired/repairable and remaining 111178[41] DTs (93.30 *per cent*) were declared condemned and sold/ disposable in scrap.

It was noticed that JVVNL decided (November 2015) to dispose of all the single phase BGP failed DTs. Further, JVVNL decided (July 2016) to dispose of three phase BGP failed DTs having manufacturing date prior to 1 April 2010 considering that repairing of BGP failed DTs were not economically viable in comparison to purchase of new transformers. We observed that all the BGP failed DTs declared condemned and sold/disposable during the period 2015-18 were manufactured between April 2006 and March 2010. Thus, instead of prescribing norms for periodic maintenance/ safeguard of DTs *viz.* periodic inspection of load, temperature and voltage, oil level, earth resistance, relay, alarms and circuits *etc.*, the Company decided to dispose of old BGP failed DTs thereby reducing the effective utilisation period of DTs from fair life of 25 years to 11 years and incurred loss of ₹ 122.90 crore[42] on account of condemnation and disposal of BGP failed DTs.

2. Year-Wise DT Purchase Cost of JVVNL

FY	Transformer Rating (kVA)	Phase (1 Ph/ 3 Ph)	Per Unit Price
2016	25	1	68809.52
2016	25	1	72250
2016	16	3	39870
2016	16	3	58000
2016	10	3	30428.95
2016	25	3	45000
2016	500	3	572442.25
2017	16	1	53245
2017	10	1	43472.5
2017	16	1	51527.95
2017	25	1	73590.46
2017	10	1	42365.14
2017	160	3	132004.07
2017	63	3	69771.38
2017	100	3	98123.75
2017	500	3	538144.41
2017	40	3	60000
2018	10	3	45299.77
2018	63	3	77507.55
2018	100	3	101487.18
2018	16	3	36996
2018	315	3	385093
2019	5	1	28792
2019	10	1	33500
2019	16	1	42480
2019	25	1	58100
2019	10	1	33500
2019	40	3	65999.59
2019	40	3	65999.59
2019	63	3	81656
2019	100	3	103325
2019	160	3	152851.21
2019	250	3	364915
2019	315	3	610000
2019	500	3	690000
2019	10	3	52300
2020	500	3	660771.51
2020	16	3	47251
2020	500	3	660771.51
2020	315	3	448750
2020	63	3	85850.9

FY	Transformer Rating (kVA)	Phase (1 Ph/ 3 Ph)	Per Unit Price
2020	100	3	113750.82
2020	10	1	30711
2020	16	1	38711
2020	25	1	52971
2020	25	1	52971
2020	25	1	52971
2020	25	1	52971
2020	5	1	29788.72
2020	5	1	29800

(Note: Data shown above is provided by JVVNL. Whereas authors have not given complete set of data as it is only for reference purpose to understand weighted average DT purchase cost derived in Para. 4.3 Table 8)

3. DT Purchase Cost of Jodhpur Vidyut Vitran Nigam Limited (JdVVNL)

Rate of Transformers Jodhpur Vidyut Vitran Nigam Limited (JdVVNL) has been referred and values are obtained from tender document of JdVVNL.

"……..
The stores issue rate of transformer, as per Standard Issue Rates are as below:

S.NO.	TRF. RATING (IN KVA)	ALL ADJUSTED PRICE (IN RS.)
1	16 KVA, three phase (Copper Wound TFRs.)	47,150.00
2	16 KVA, three phase w/o M&P Box	39,750.90
3	25 KVA, 3-phase w/o M&P Box	45,883.85
4	40 KVA, 3-phase w/o M&P Box	64,251.65
5	63 KVA, 3-phase w/o M&P Box	83,165.10
6	100 KVA, 3-phase w/o M&P Box	1,12,495.30
7	160 KVA three phase	1,59,432.76
8	250 KVA three phase(Copper Wound TFRs.)	2,01,656.08
9	315 KVA three phase(Copper Wound TFRs.)	5,02,448.64
10	500 KVA three phase(Copper Wound TFRs.)	6,75,248.26

The gross estimates in respect of the transformers be considered as within the prescribed economical limit of 38% (thirty eight percent) of the store issue rate(s) of new three phase transformer(s)…."