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Distribution Transformers (DT) – Enhancing Energy Efficiency & Reliability through Performance-based Refurbishment Contract – A Case

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Legacy DTs improvement at DISCOM

1

Loss Reduction

Total Technical Losses reduction

2

Reliability Improvement

Reducing DT Failure rates

3

kVA Capacity Enhancement

Increasing kVA capacity of DTs to allow higher % loading

No choice except repairing failed DT to serve our customers

Reasons For High Technical Losses

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No Load losses	Full Load losses
1) High Flux density (Tesla > 1.5) at design stage of DT manufacturing	1) High current density during design stage of DT manufacturing (1.4-1.5 Amp/mm ² for Al and 3 Amp/mm ² for Cu)
2) Bad quality of core with improper coating and high thickness	2) Replacement of original coils with derated (smaller size) coils during repairs
3) Successive degradation because of loss of core material during repairs	3) Replacement of electrolytic grade coils (conductors) with commercial grade coils
4) Reduction in no. of turns during refurbishment or repairs	

How To Reduce Loss Levels In DT

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Measures	No Load Loss	Load Loss	Cost
Decreasing No Load Loss			
Use Low loss core material	Lower	No Change	Higher
Decrease flux density by 1. Increasing Core Cross section area 2. Decreasing Volts/Turn	Lower	Higher	Higher
Decrease flux path length by decreasing conductor Cross section	Lower	Higher	Lower
Decreasing Load Loss			
Use low loss conductor material	No Change	Lower	Higher
Decrease current density by increasing conductor cross section	Higher	Lower	Higher
Decrease current path length by 1. Decreasing Core cross area 2. Increasing Volts /Turn	Higher Higher	Lower Lower	Lower Higher

Issues And Challenges In Current Refurbishment Process

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Awareness: Conventional refurbishment is the prevalent practice with DISCOM; performance-based one is in nascent stage among utilities

Regulatory: Approval of capex proposals (including DT) without impact evaluation of earlier approved capex (i.e. whether the asset last to its full lifetime and so on), dilutes the prudence.

Cost Accounting Mechanism in DISCOM: Current system not designed to capture recurring cost (i.e. repair cost) on a particular DT across its lifetime, to track the OPEX and total cost. This can enable both Licensee & Regulator to raise flag when the costs are beyond limits. Having such system will improve the procurement expenditure (i.e. Capex) by reform of the procurement conditions.

Commercial: Conventional refurbishment appears less expensive at first sight, however it is concealing the total cost of ownership/operation of legacy DTs

Contractual: Contractual challenges with most existing refurbishment agreements includes

- Short warranty period i.e. minimal control on performance
- No checks & balances on reliability of DT performance post refurbishment (for outside warranty DT's)
- No mechanism/contractual obligation for measuring the energy performance of DT post refurbishment other than the prevailing acceptance tests

Issues and Challenges In Current Refurbishment Process

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Slide 2 of 2

Monitoring Mechanism:

- Absence of strong monitoring mechanism to narrow down on DT failure reasons
- Absence of continuous energy performance monitoring of DT's, to ascertain the quality of functioning of DT

Repair Ecosystem:

- Apprehension from DISCOM about higher cost of performance-based refurbishment (without weighing the long-term commercial benefits)
- Apprehension from repairer about potential changes in legacy refurbishment system/process, as current system is not outcome/performance driven
- Absence of capacity/awareness with repairers/DISCOM to have transition from conventional repair to performance-based refurbishment



PERFORMANCE IMPROVEMENT REFURBISHMENT

What is Performance Based DT Refurbishment?

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Focuses on technical loss reduction and key asset (DT) upgradation

Achieves through winding compensation

- Replacing Al with Cu winding
- Both HT and LT windings or only one of them can be replaced

Winding compensation allows scalable refurbishment methodology

- Changing different size core will be a challenge

Strong Service Level Agreement (SLAs) driven with performance-based incentives to the repairer

- Repairer can be incentivized over rate contract, depending on the technical losses reduction over baseline losses or capacity enhancement

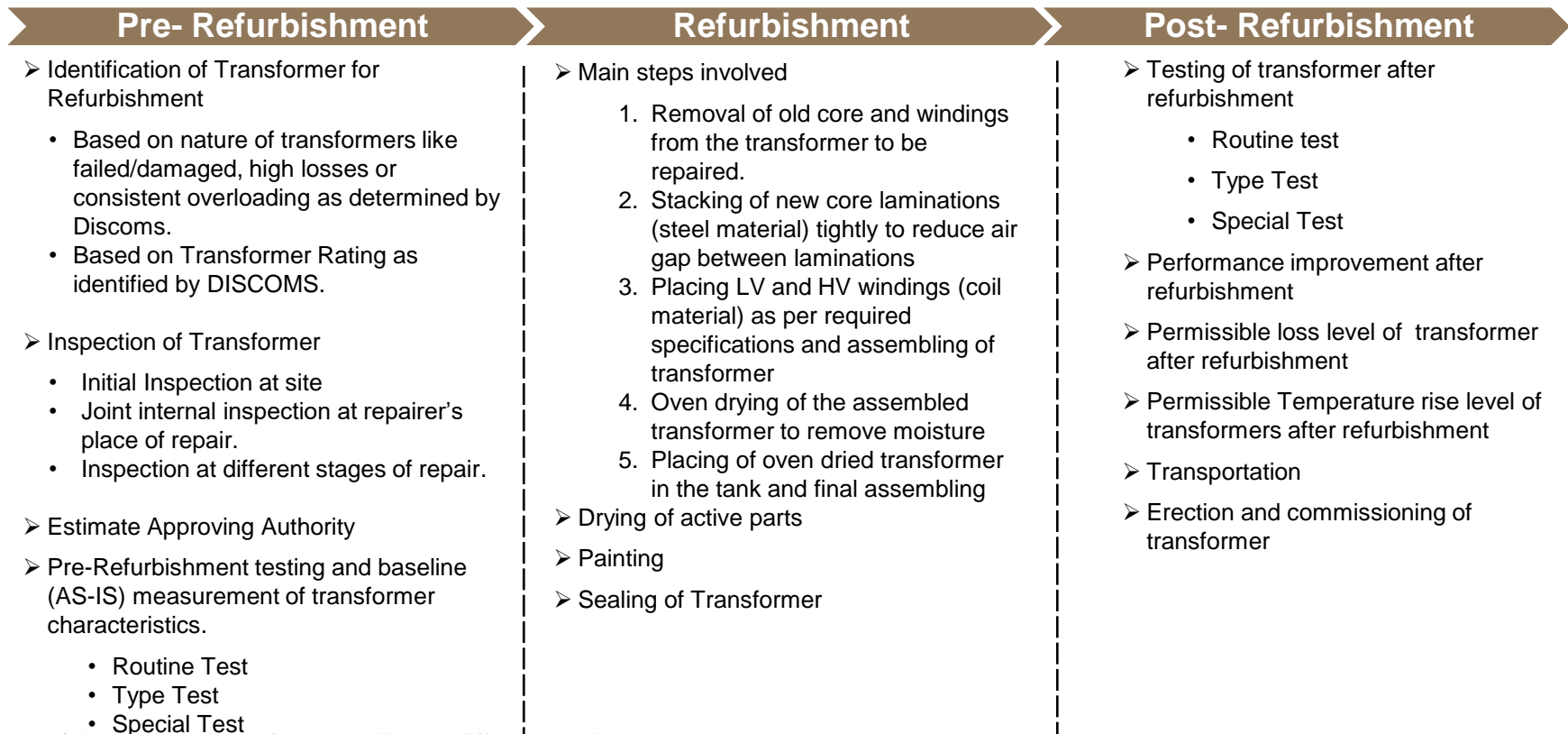
Can be applied selectively on DTs that yield preferred payback period

- Guideline can be prepared to undertake it on DTs with higher technical losses only
- Pre- refurbishment testing of No load and Full load losses should be mandated to evaluate performance-based refurbishment applicability

Overview of Process of Performance based Refurbishment of DT

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Performance based refurbishment shall be carried out of failed/damaged/legacy distribution transformer and also the distribution transformer with high total losses and consistent overloading to improve its performance including Reducing technical losses i.e. Total Loss (No load loss + Load loss); Improving reliability and reducing downtime (i.e. Mean Time Between Failures); and Increasing kVA capacity of the distribution transformer



Methodology

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Pre- refurbishment Testing, Execution and Post- refurbishment Testing at MTRU;
Independent Testing





PILOT: 200KVA DT, MPPKVVCL

Solution & Results, Cost Benefit Analysis

Performance Improvement Repair Solution and Results

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200 kVA DT was selected for performance improvement repair. HT windings were replaced. LT retained. Helped in cost optimisation. Significant Full Load loss reduction was obtained.

Key Design Parameters	Unit	Utility Specs	Baseline Pre-repair (at MTRU)	Actual Post-repair (at ERDA)	% Change from Base-Line
Capacity	kVA	200	200	200	
Year of Manufacturing			2013		
LV Winding Material			DPC Al	DPC Aluminium	
# of LV Turns	#		42	42	
HV Winding Material			DPC Al	DPC Copper	
# of HV Turns	#		1848	1848	
No Load Loss	Watts	500 (+15 % IS Tol.) = 575	652	652	0%
Full Load Loss	Watts	3000 (+15% IS Tol.) =3450	3450	2377	-31%
Impedance	%	4.5	-	4.2	
Total Winding Weight	Kg		100.5	178	

This also gave an insight into Hybrid Design in DT for better reliability and efficiency at an optimised cost

Cost Benefit Analysis

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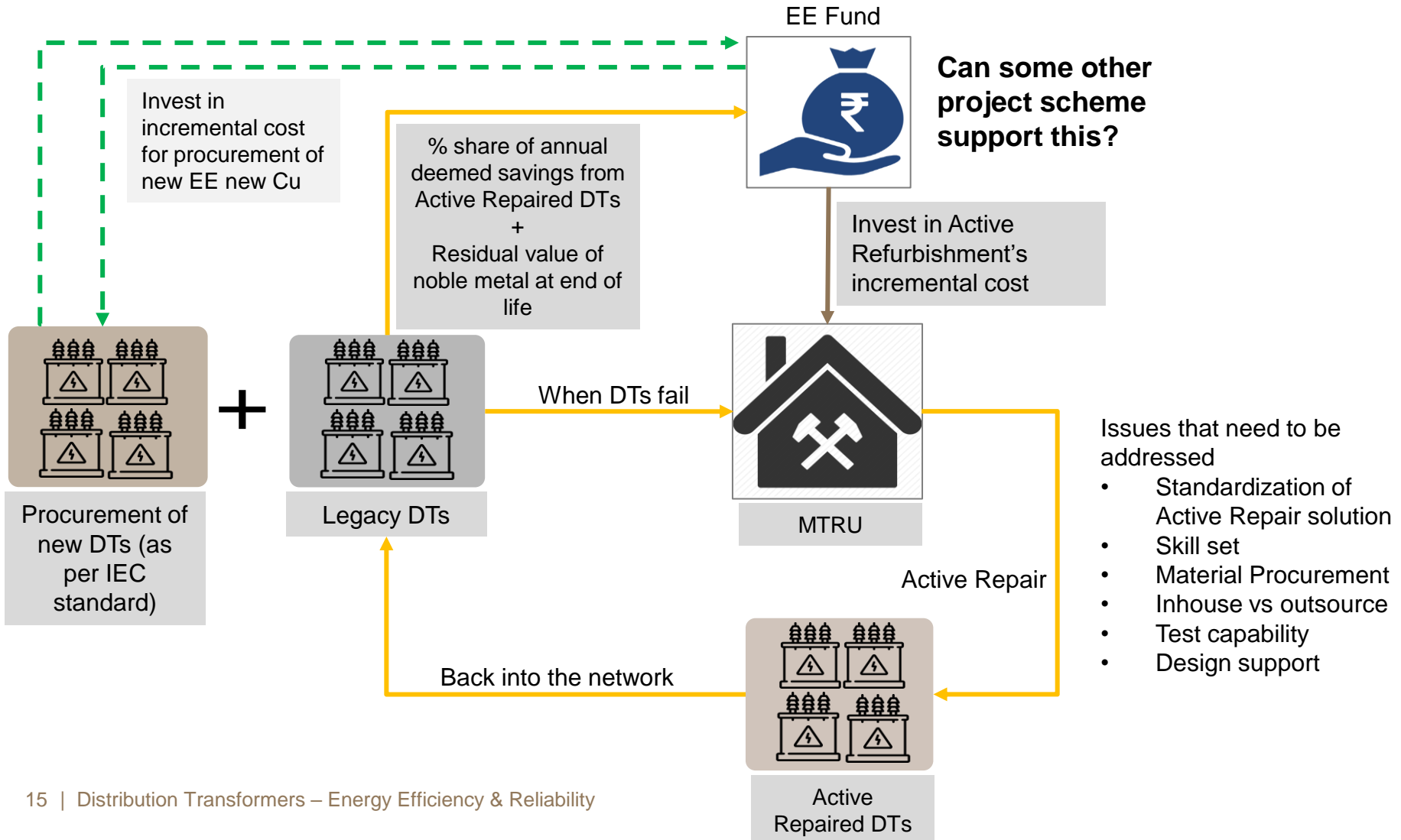
Refurbishment or 'Active Repair' provides good cost economic option to Discom to upgrade legacy DTs asset with performance (measured in terms of Total Loss) equivalent to a level of EE as per IS 1180

Cost Benefit Analysis	
Total Units Saved (kWh/year)	9,399
Avg. Revenue (Rs./kWh)	6.25 (8 Cents)
Total Cost for Active Repair (INR)	90,290 (1200 USD)
Total Cost for Conventional Repair (INR)	19,973 (270 USD)
Incremental Cost (INR)	70,317 (930 USD)
Simple Payback Period including financing charges (years)	1.29



POTENTIAL BUSINESS MODEL

A Possible Business Model



Benefits from Performance Based Repair and Stakeholders Alignment

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Benefits to Utility

- Improvement in efficiency due to reduction in technical losses
- Reduction in failure rate of DTs
- Improvement in asset management practices
- Reduction in O&M expenses thereby improvement in financial health
- Capex optimization by opting for R&M of DT in place of procuring new DT thereby reducing tariff impact

Benefits to the DT Repairer/ Manufacturer/ Service provider

- Opportunity to do regular business and get added value through performance improvement during repair

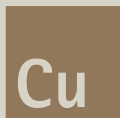
Benefits to end Consumers

- Improvement in power quality and reliable supply
- Reduction in tariff

Thank You

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