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

Manas Kundu

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# Objectives

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## Legacy DTs improvement at DISCOM

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### 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

| 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<br>1. Increasing Core Cross section area<br>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<br>1. Decreasing Core cross area<br>2. Increasing Volts /Turn | <br>Higher<br>Higher | <br>Lower<br>Lower | <br>Lower<br>Higher |

# Issues And Challenges In Current Refurbishment Process

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## Slide 1 of 2

**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 prudency.

**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 toa 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



**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

## Pre- Refurbishment

- Identification of Transformer for Refurbishment
  - Based on nature of transformers like failed/damaged, high losses or consistent overloading as determined by Discoms.
  - Based on Transformer Rating as identified by DISCOMS.
- Inspection of Transformer
  - Initial Inspection at site
  - Joint internal inspection at repairer's place of repair.
  - Inspection at different stages of repair.
- Estimate Approving Authority
- Pre-Refurbishment testing and baseline (AS-IS) measurement of transformer characteristics.
  - Routine Test
  - Type Test
  - Special Test

## Refurbishment

- Main steps involved
  1. Removal of old core and windings from the transformer to be repaired.
  2. Stacking of new core laminations (steel material) tightly to reduce air gap between laminations
  3. Placing LV and HV windings (coil material) as per required specifications and assembling of transformer
  4. Oven drying of the assembled transformer to remove moisture
  5. Placing of oven dried transformer in the tank and final assembling
- Drying of active parts
- Painting
- Sealing of Transformer

## Post- Refurbishment

- Testing of transformer after refurbishment
  - Routine test
  - Type Test
  - Special Test
- Performance improvement after refurbishment
- Permissible loss level of transformer after refurbishment
- Permissible Temperature rise level of transformers after refurbishment
- Transportation
- Erection and commissioning of transformer

# Methodology

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

**Received DT**

**Pre-repair testing (open circuit and short circuit test) with Discom representatives**

**Designing Solutions for Active Repair**

**Active Repair Execution**

**Post Repair testing with Discom representatives**

**Repaired DT**

**Connecting the DT in network Transformer**

**Final Installation**

# PILOT: 200KVA DT, MPPKVVCL

## Solution & Results, Cost Benefit Analysis

# Performance Improvement Repair Solution and Results

**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

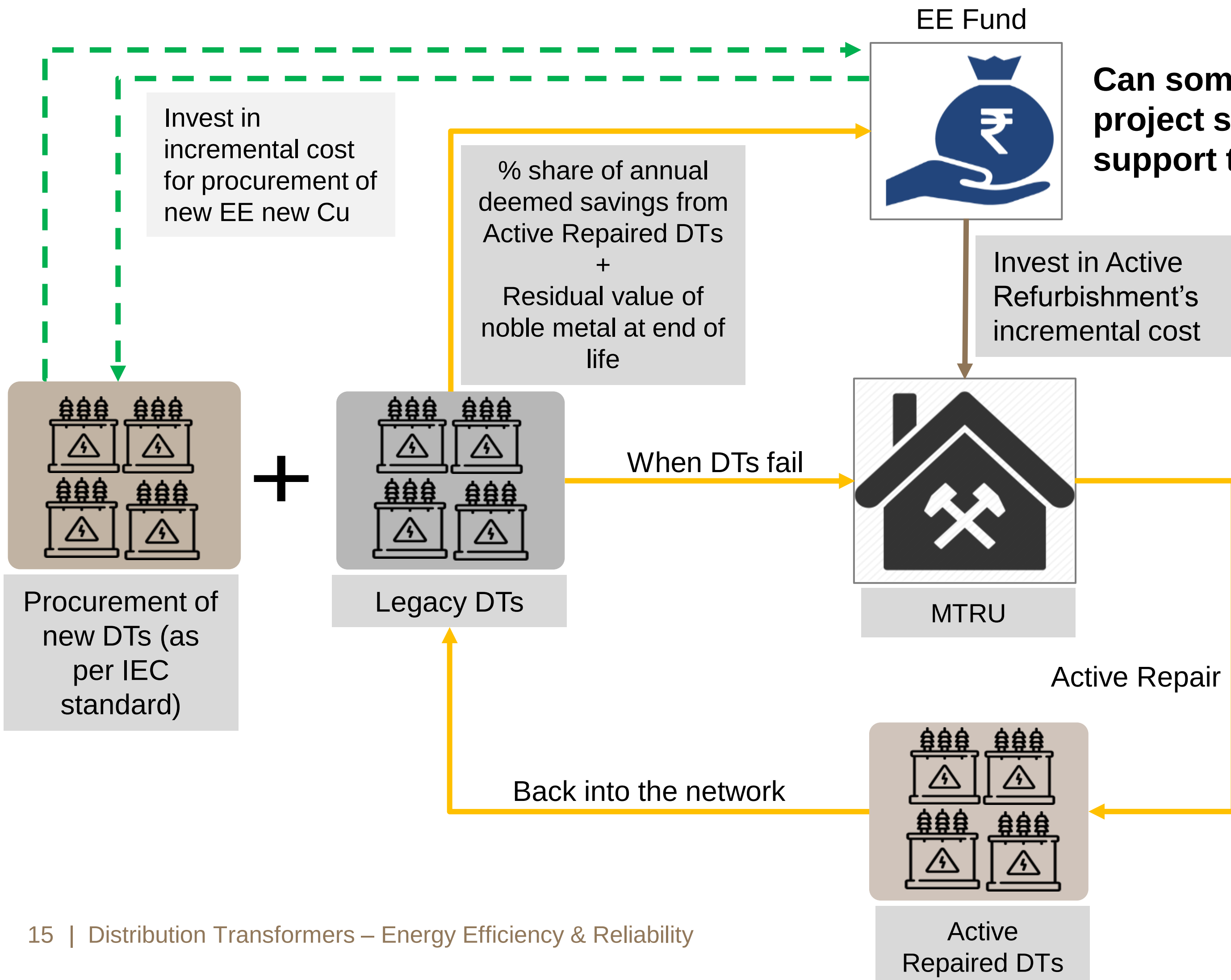
# Cost Benefit Analysis

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




**Can some other project scheme support this?**

Issues that need to be addressed
- Standardization of Active Repair solution
- Skill set
- Material Procurement
- Inhouse vs outsource
- Test capability
- Design support

# Benefits from Performance Based Repair and Stakeholders Alignment

## 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

manas.kundu@copperalliance.org

mayur.karmarkar@copperalliance.org

International Copper Association Asia
Copper Alliance