Industry NAVIGATOR

SUSTAINABLE DEVELOPMENT STRATEGIES FOR T&D

CONFERENCE 2025

Advancing Sustainability in T&D by Optimizing the Use of Transformer Assets

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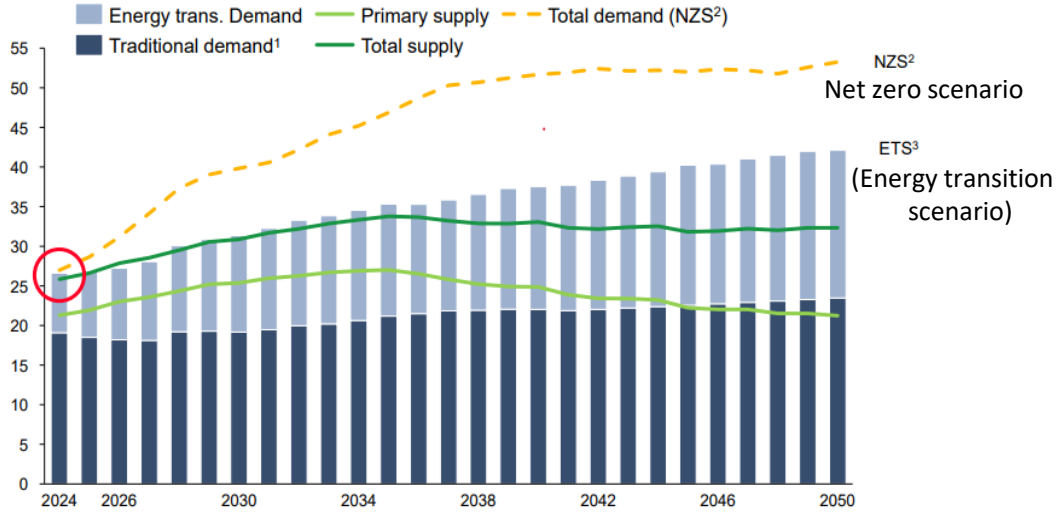
Contents

Global challenges for new transformers sourcing

Global energy transition towards renewable energy and rapid electrification is driving a significant increase in transformer demand worldwide.

- **Shortage of supply**: lead time almost double in average recent years
- **Raising cost**
- **Uncertain in price due to long lead-time**
- ➢ ***Delays in grid connection for renewables**, more **power outages** due to aging assets & **delay housing construction***



Environmental impacts from increased demand of materials

- **Raw material scarcity:** demand expected to surpass production capacities in mid-term for Copper (*)
- **Pollution, ecosystem imbalance and water scarcity**: with the growth of mining capacities
- **Significant GHG emissions:** from extraction, treatment, processing and transport of huge material quantity

Source (*) BNEF – Transition Metal Outlook 2024

The Transformers installed base - Reality and challenges today

Low average load-factor of majority T&D transformers

- Transmission & Large distribution
  - Majority N-1 configuration
  - Operate at **below 50 %** loading (peak)
- Distribution: Low load operation seen in many countries

Short Lifetime of power transformers in many utilities across the region

- The presumed lifetime of transformers ranges from **25 - 35 years** (even shorter) possible reasons could be:
  - Substandard manufacturing processes & quality
  - Poor maintenance
  - Low risk approaches for retirement decision
  - Failures due to external parts:

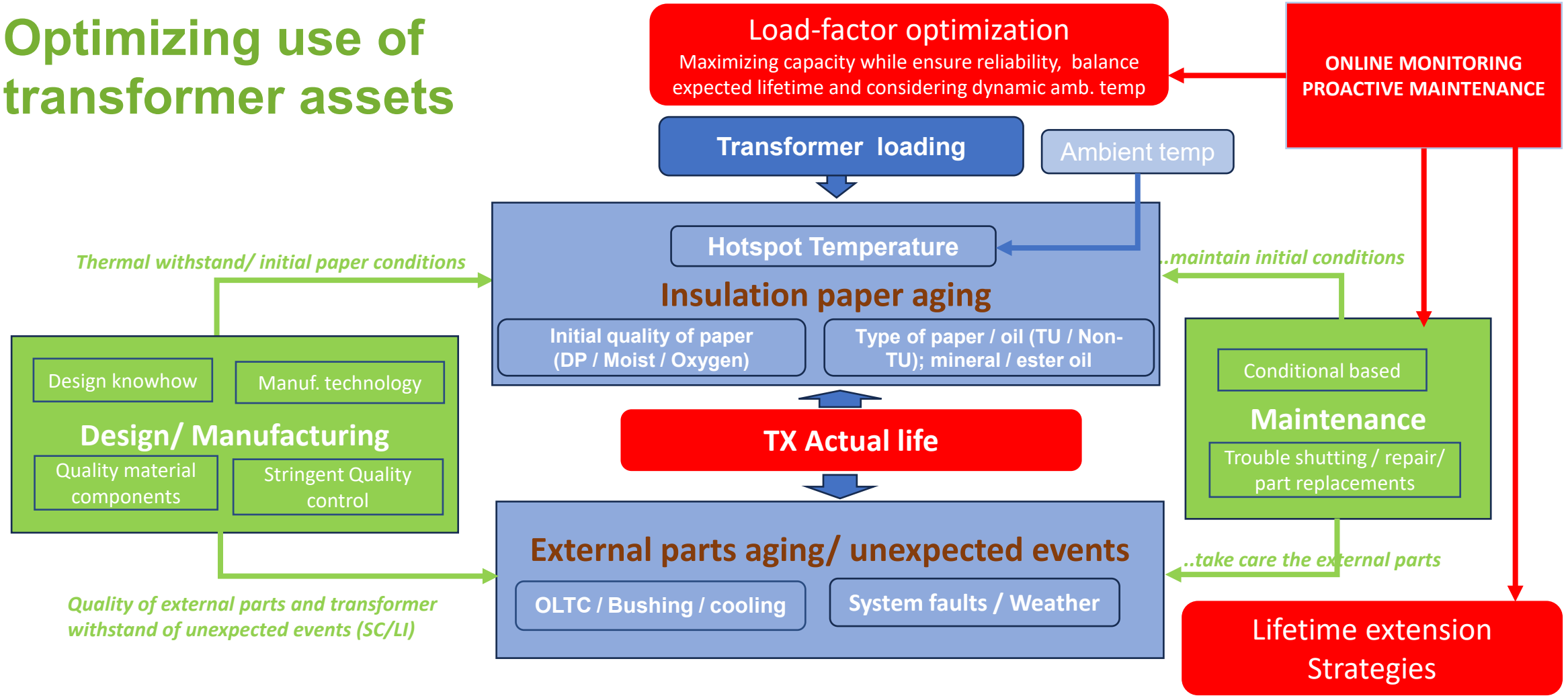
Country	Yearly average load factor (PU)
Australia	27 %
Canada	34 %
China	50 %
European Union	21 %
India	Unknown
Japan	22 %
USA	34 %
Indonesia	50 %
Thailand	36 %
Mexico	31 %

Estimate average load of distribution transformer, 2014 [*]

While many other utilities record a lifespan of 60 - 70 years, it appears there are opportunities for better use of existing assets in many regions.

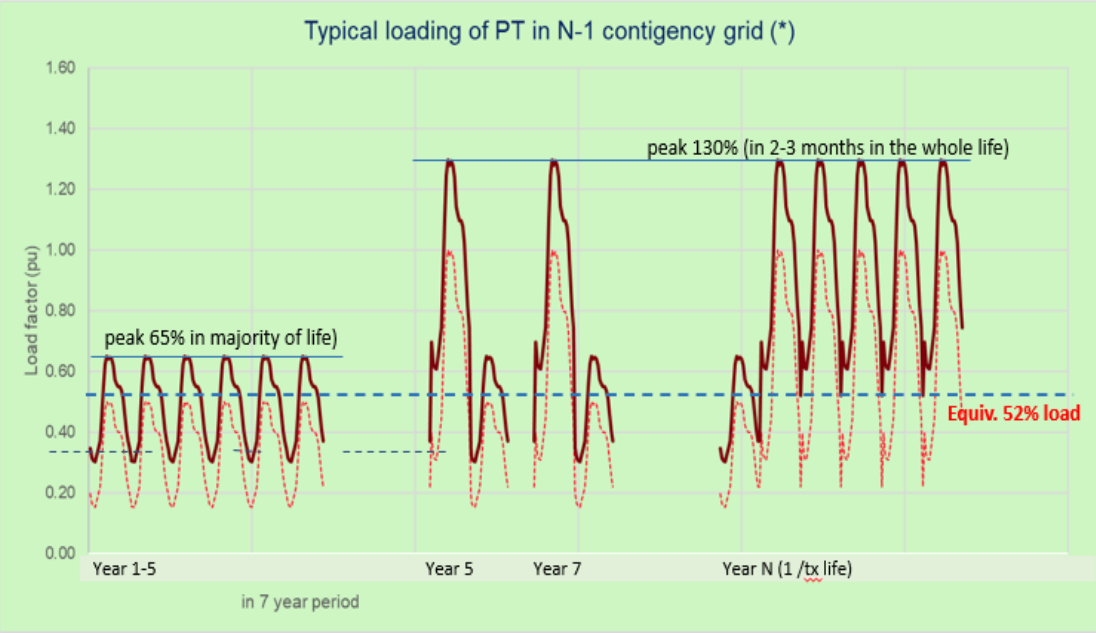
Source (*) Waide Strategic Efficiency and N14 Energy Limited, PROPHET II: The potential for global energy savings from high-efficiency distribution transformers, 2014.
(**) CIGRE WG A2.37 Transformer Reliability Survey 22015

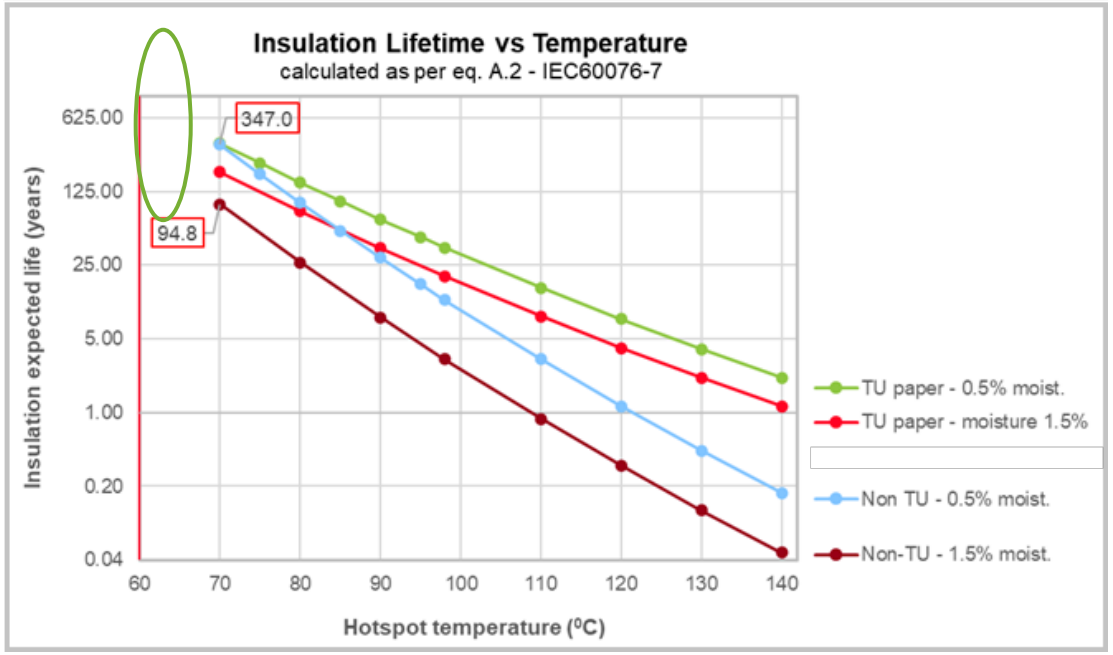
Optimizing use of transformer assets



Load-factor optimization – Power Transformer

Added 15% loading to max 130% (longtime emergency loading mode)





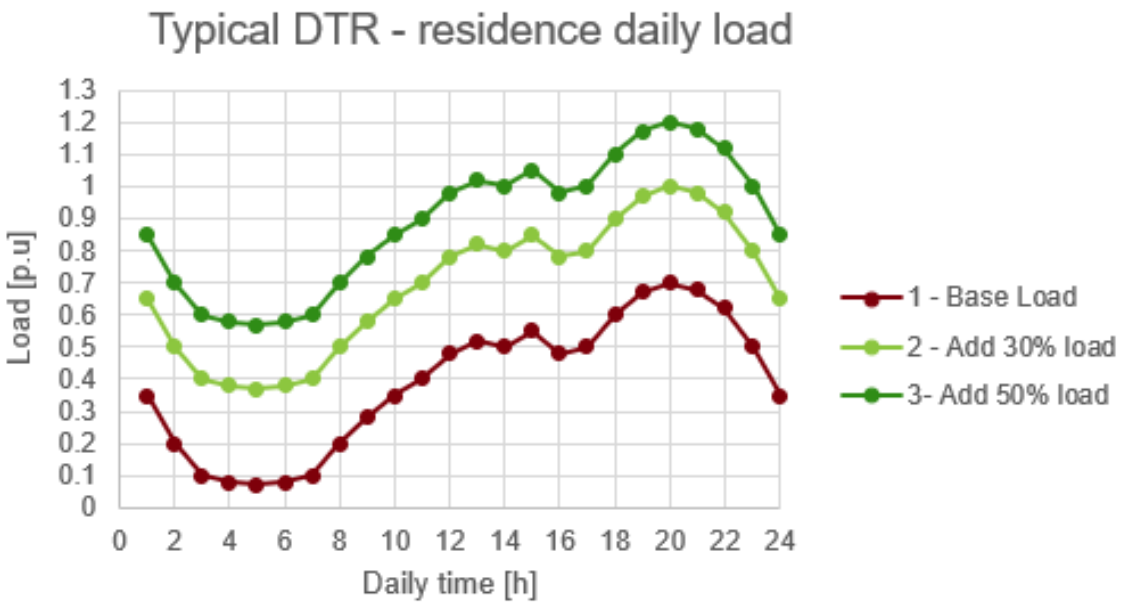
Calculated in a typical design of Large and Medium PT

TX type	Temp. rise TO/HST (0C)	Amb. temp (^{0}C) anual/max	Limited loading (TO:110/ HST 140^{0}C	Eq. Load (pu)	Eq. HST (0C)
75MVA	50/68	30/40	130%	0.52	56.5

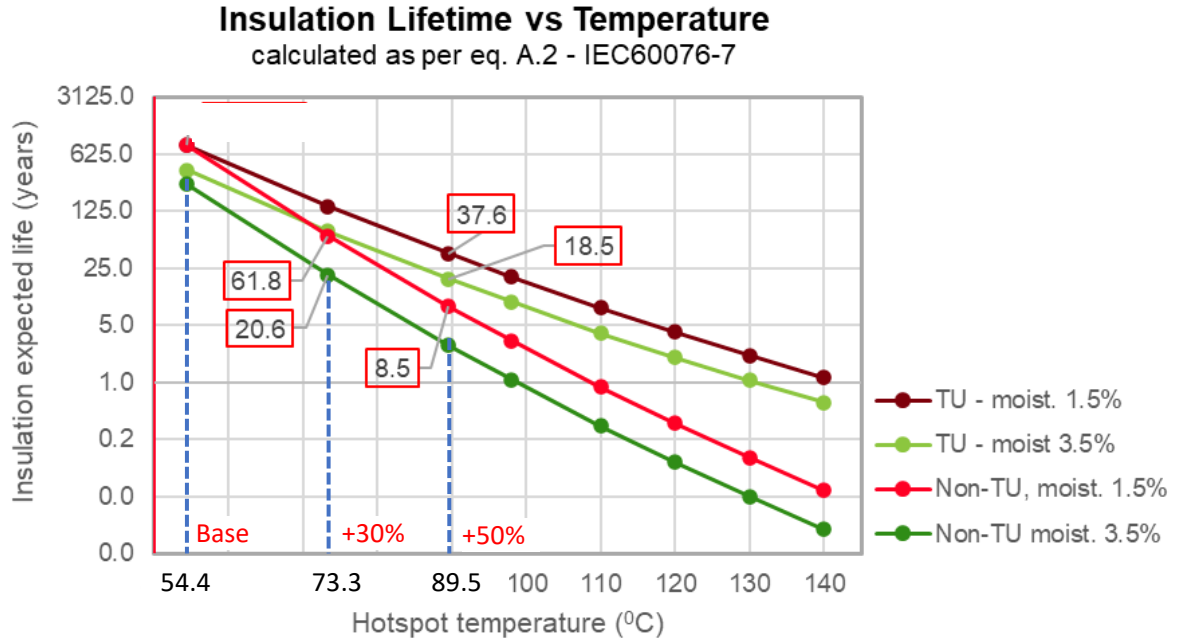
- ✓ **Potentially long life expected for PT in N-1 contingency grid**
- ✓ **Load can be added to limit level at ignorable reduced lifetime**

(*) Typical data from on a transmission network from one Asia utility

Load-factor optimization – DTR



TX type	Temp. rise TO/HST (0C)	Amb. temp (^{0}C) anual/max	Limited loading (TO:110/ HST 140^{0}C	Loading case	Eq. Load (pu)	Eq. HST (0C)
DT	50/68	30/40	130%	1- Base load	44%	54.4
				2- Added 30% load	72%	73.3
				3- Added 50% load	91%	89.5

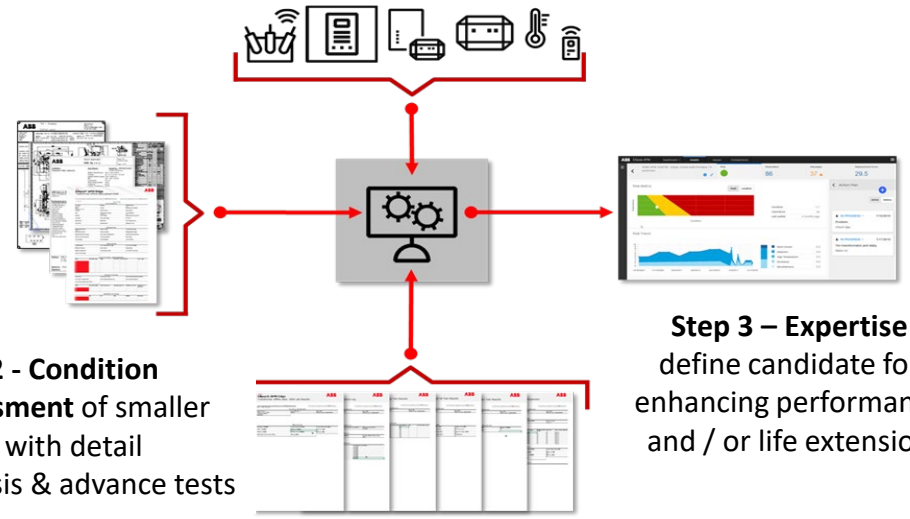


- Load-factor can be increased without compromising lifetime and adding new transformers. Assessment based on actual transformer design & its current condition.
- Load-factor improvement potentially for large quantity of DTR in T&D
- Thermally upgraded paper recommended for new DTRs for improved lifetimes at increased load-factor.

Lifetime extension strategies

Everything starts with a condition assessment, putting reliability in a center of maintenance strategy.

Step 1 – Fleet screening survey: Collecting easily accessible data: nameplate, drawings, FAT reports, load profiles, historical operation & current online data

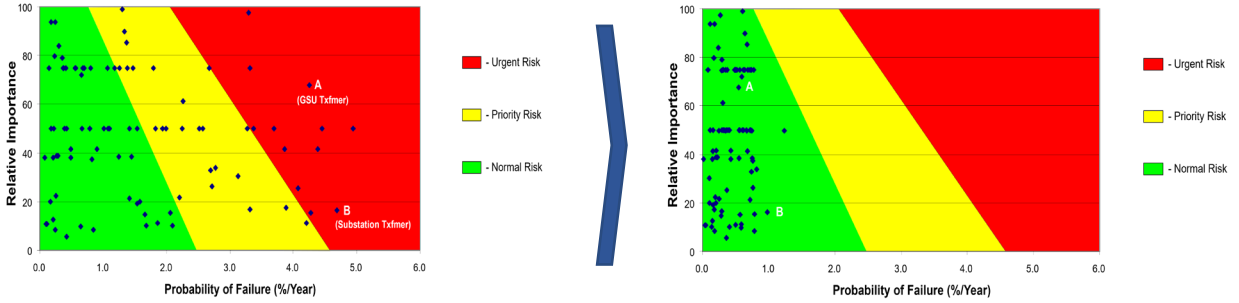


Step 2 - Condition assessment of smaller group with detail analysis & advance tests

Step 3 – Expertise define candidate for enhancing performance and / or life extension

Condition Assessment Methodology incorporate algorithms that leverage OEM expertise and decades of experience.

"Asset Performance Management by Hitachi Energy APM Edge / Lumada APM, which is part of TXpert Ecosystem, helps prioritize transformer fleet condition assessment through a structured approach around electrical, mechanical, thermal conditions, insulation ageing, and the status of key components in the transformer, based on its reliability and the importance for the electrical grid customers."



Initial assessment result on a transformer fleet

Assessment after action plan on the same transformer fleet

Making informed decisions along transformers fleet renovation and lifetime extension.

Lifetime Extension – Onsite Refurbishment

End of Life

Transformer Life Extension aligns the goals of reliability, sustainability and resources efficiency

Case 1

- **60 aged transformer**
- Numerous leaks, aged oil & accessories.

Case 2

- **55 aged transformer**
- Oil leaks, defective breathers, old bushings

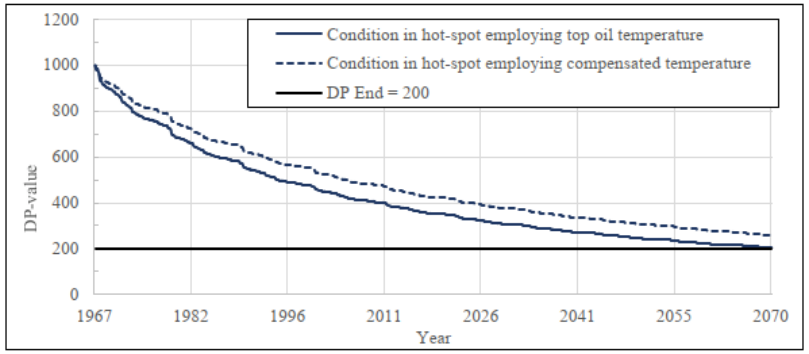
Comprehensive list of recommendations including

- Transformer inspection and condition assessment
- Refurbishment scope
  - Bushing & accessories replacement
  - Tank welds repair
  - Oil replacements / Vacuumed oil filter/filling
  - Dry out / re-test

Refurbishment Hitachi Energy at customer site

- On time delivery: **in 4 weeks completion/** saving **~15 months** compare with building new transformer
- Circularity: More than **90 % materials reused**

Transformer- case 1 [*]



Degree of polymerization estimation – case 2 [*]

[*] Source: 10546 Transformer Sustainable Refurbishment for Ultra Long-Life

Lifetime extension – Onsite Repairs

TrafoSiteRepair™ enhances reliability, reduce costs, and shortens delivery times while also promoting sustainability.

Solution provided…

- Clean environment
- High skilled workforce
- Robust quality processes
- Advance drying process
- High voltage dialectical testing

End of Life

On-site Repairs aligns the goals of reliability, sustainability and resources efficiency

Transformer Specifics

- 440 MVA // 400 / 230 / 25.5 kV
- Core Type – Hitachi Energy (Legacy)
- GSU - Italy

Comprehensive list of recommendations including

- Transformer inspection and condition assessment
- TrafoSiteRepair™ including within the scope:
  - Winding replacement & Core & C&L retrofit
  - Active part drying by LFH and retighten
  - Gasket and hardware replacement
  - New oil
  - HV Testing as per IEC standard

TrafoSiteRepair™ by Hitachi Energy at customer site

Virtual factory to site. Quality, safety and environmental as in Factory.

On time delivery	**TrafoSiteRepair™**	**11 months**
	New TR	24 months (EXW)

Reliability

Reduce costs

Shorten time

Sustainability

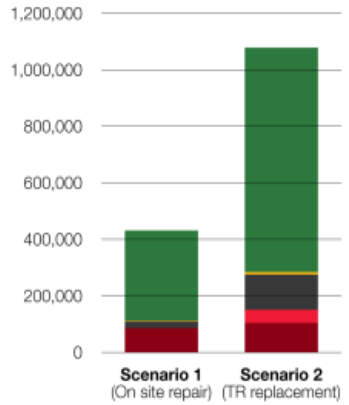
Lifetime extension - Onsite Repairs

Transformer Life extension brings huge environmental benefits by reducing GHG emission, enable circularity rate, minimizing waste and reducing demand for virgin raw material

Sustainability Outcome…

Start of Life

Transformer Carbon Footprint
(Climate change total Kg $CO_{2\,eq}$) - Case A



	Scenario 1 (On site repair)	Scenario 2 (TR replacement)	Data referred to baseline - Scenario 2
TOTAL:	420,263 Kg CO_{2eq}	1,079,891 Kg CO_{2eq}	
Manufacturing upstream	319,016	795,217	-60%
Manufacturing core	2,933	8,800	-67%
Manufacturing upstream transportation	23,619	125,970	-81%
Downstream transportation	0	46,615	-100%
Downstream EoL	84,694	103,289	22%

Table 5: Product Carbon Footprint - Climate Change kg CO_{2eq} - Excluded Product Use (for both scenarios will have the same impact)

- 63 %
GHG (scope 3) emission

- 500
TnCO2e vs baseline

57 %
Circularity rate (share of reused materials)

135 Tn
Waste diverted from disposal

Are you ready?

The energy transition is driving a massive increase in demand for new power transformers, challenging manufacturing, raw material capacity, and environmental impact. **Optimizing use of existing transformers** not only eases demand-supply pressures but also enhances sustainability.

01
Accelerated shift from fossil-based to renewables power generation

02
Growing electrification to more than **50 %** of total energy demand

03
Ecosystem Imbalance & Natural Resources Scarcity

2050

Transformer OEMs

Increasing
Manufacturing Capacity / Technology

Digital Solutions
Txpert Ecosystem for asset condition monitoring and assessment

Lifecyle Services
Tailored solutions for reliability, efficiency, and sustainability

TSOs / DSOs

Maximizing transformer capacity and lifespan

Load - factor optimization:
Maximizing capacity in balance with expected lifetime while ensure reliability

Lifetime extension:
Embraces sustainability and circularity around reused components and embedded carbon of critical virgin materials avoided to be disposal.

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THANK YOU !