

Transformer Life Expectancy

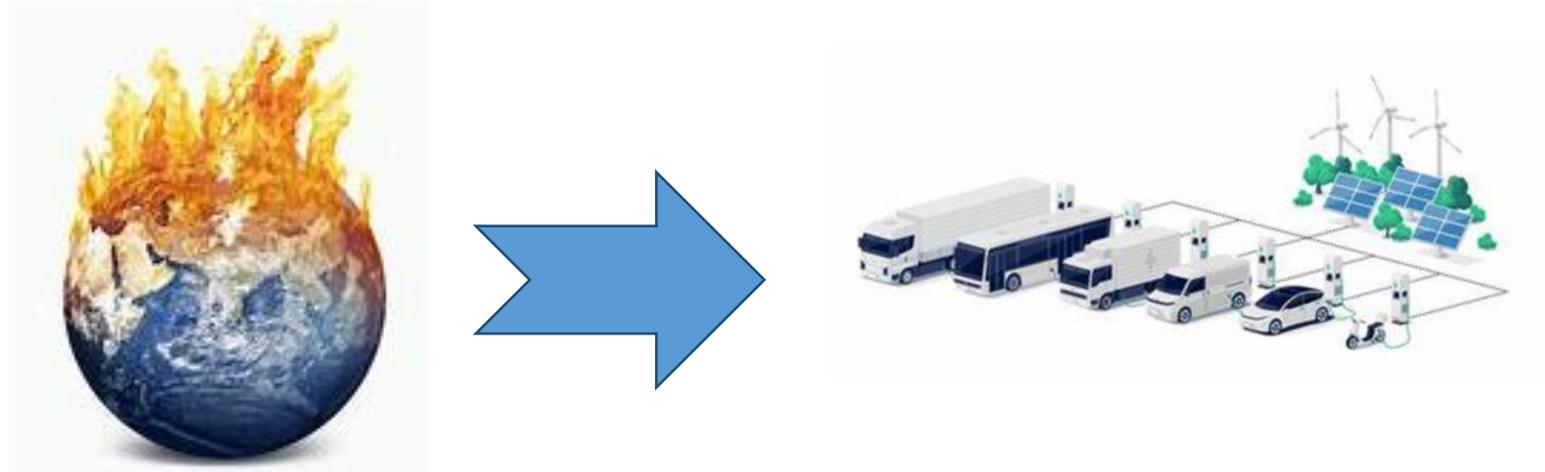
How long will your transformers last?

Leon White, PE
H2scan

Dr. Tony McGrail
Doble Engineering

Challenges of Managing the Electric Grid

- COVID recovery
- Global warming
- Severe weather events
- Carbon neutral goals
- Electric vehicles
- Renewable energy
- Supply chain



*Somehow,
the lights must stay on. . .*



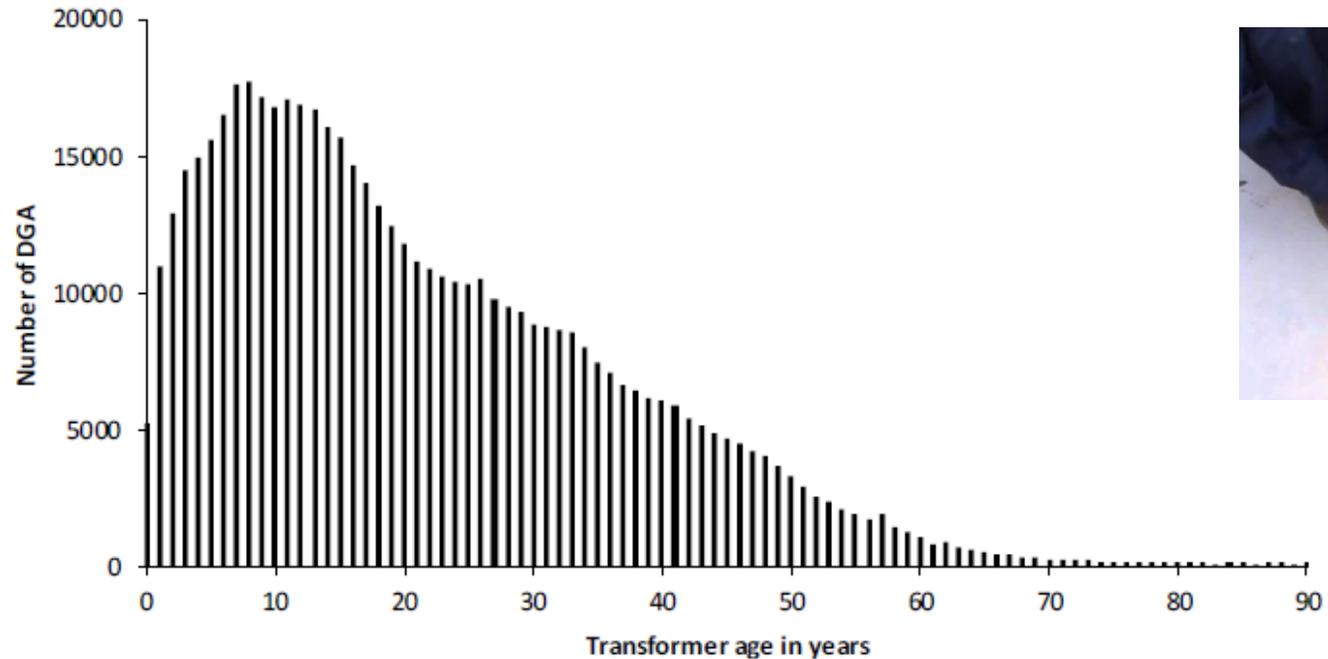
Today's Transformer Challenges

- 1 to 3+ year lead time
- 2-3X prices
- Aging fleet . . . *How much does age matter?*
- Additional load from Electric Vehicles
 - Are your transformers built to handle fast EV charge loads?
- Harmonics from solar inverters are causing premature failure
 - Will residential solar inverters reduce transformer life?



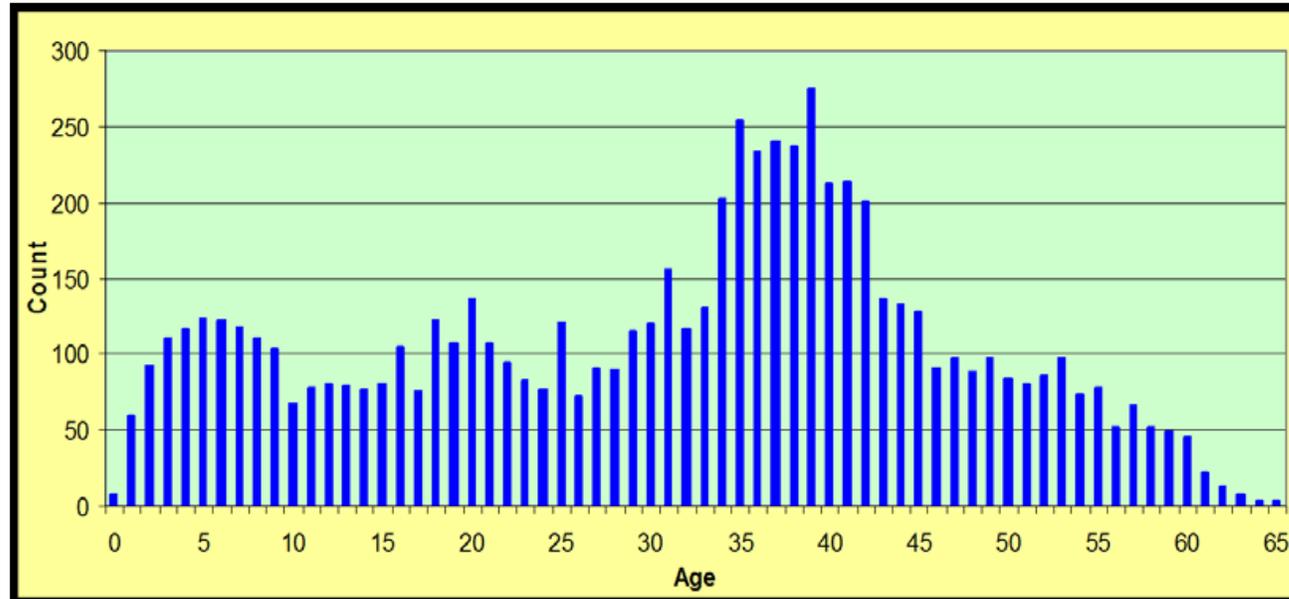
Very Little Public Data Exists On Transformer Life Expectancy

- C57.104 – IEEE Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
- Data from nearly 1.4 million oil samples from over **300,000** transformers
- Very few transformers aged 60 years and above were included in the data set.



Age Profile Data

- CIGRE Transformer Reliability Study – 2015
- Includes data from over 7000 transformers in a North American data set
- Note that chart ends at 65 years old
- How many transformers fail in-service and how many are removed from service?



Transformer Failure Modes

More than 50% of failures are caused by things external to the transformer (i.e. lightning, etc.)

ISO 18095 Power Transformer Components and Failure Modes

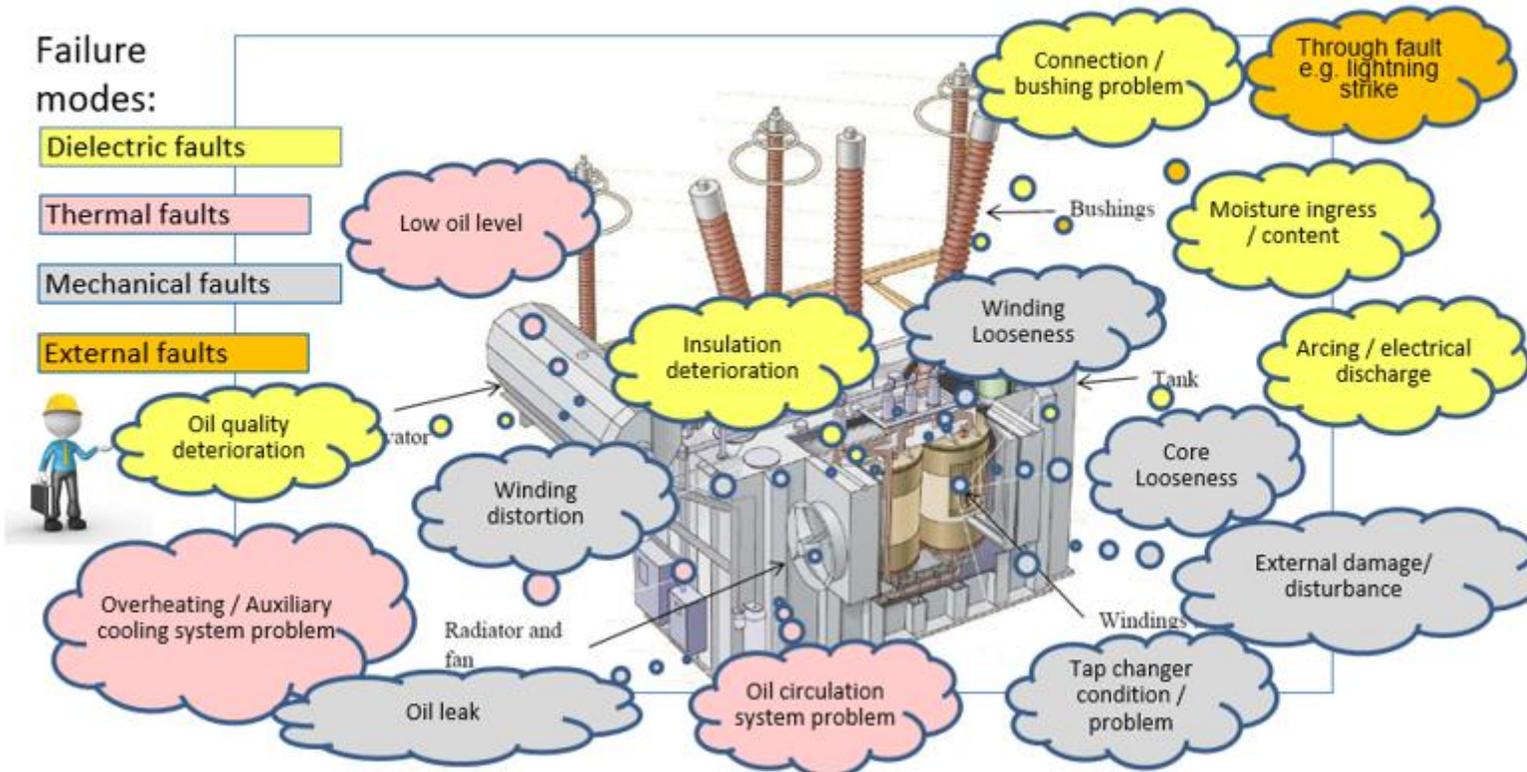
Failure modes:

Dielectric faults

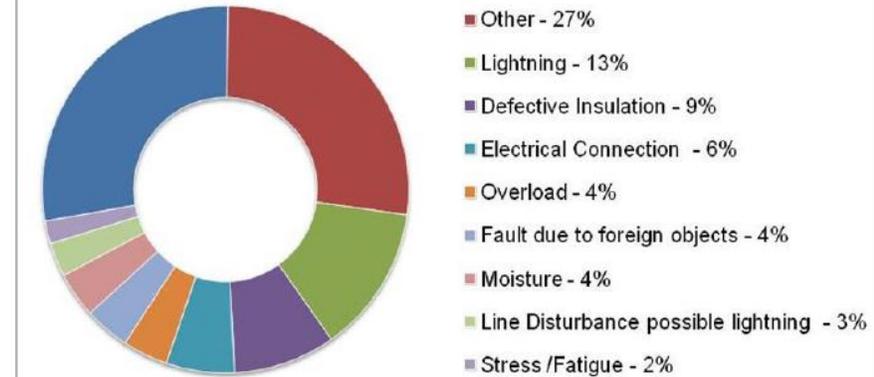
Thermal faults

Mechanical faults

External faults



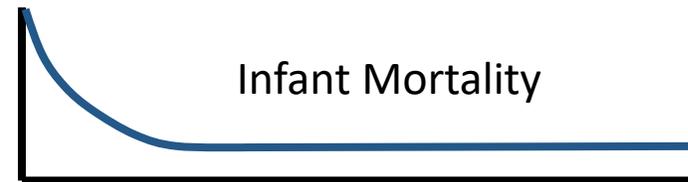
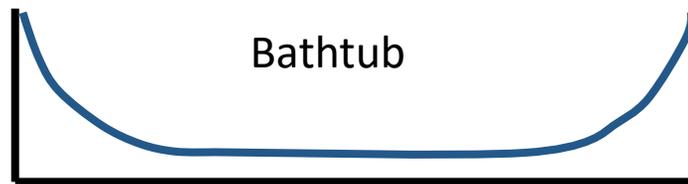
Cause of Transformer Failures



From "Analysis of Transformer Failures"
William Bartley, HSB, presented at the International
Conference of Doble Clients, Boston, 2012

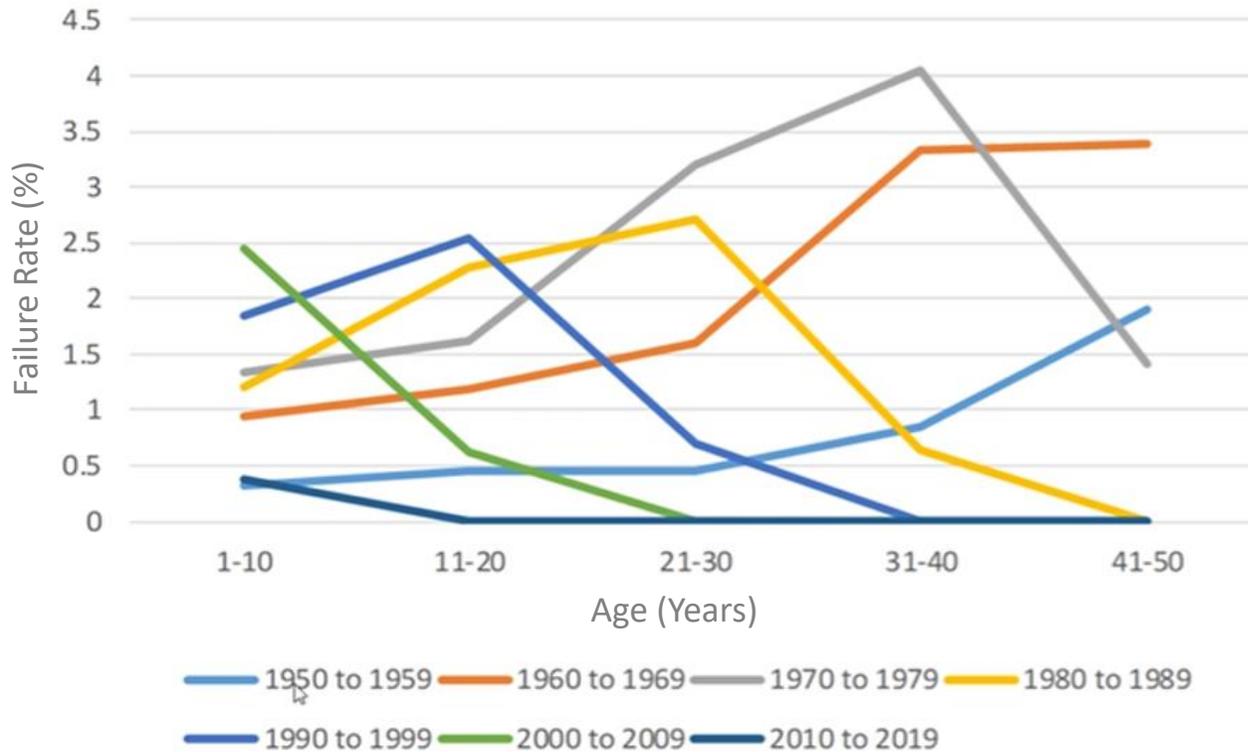
Nowlan and Heap Failure Curves

- 1978 – Engineers at United Airlines who defined various failure curves
- Reliability Centered Maintenance – Process for determining an aircraft's optimal maintenance requirements.
- Which describes transformer failures?



Transformer Failure Rates Based on Decade

- Failure data from over 25,000 transformers



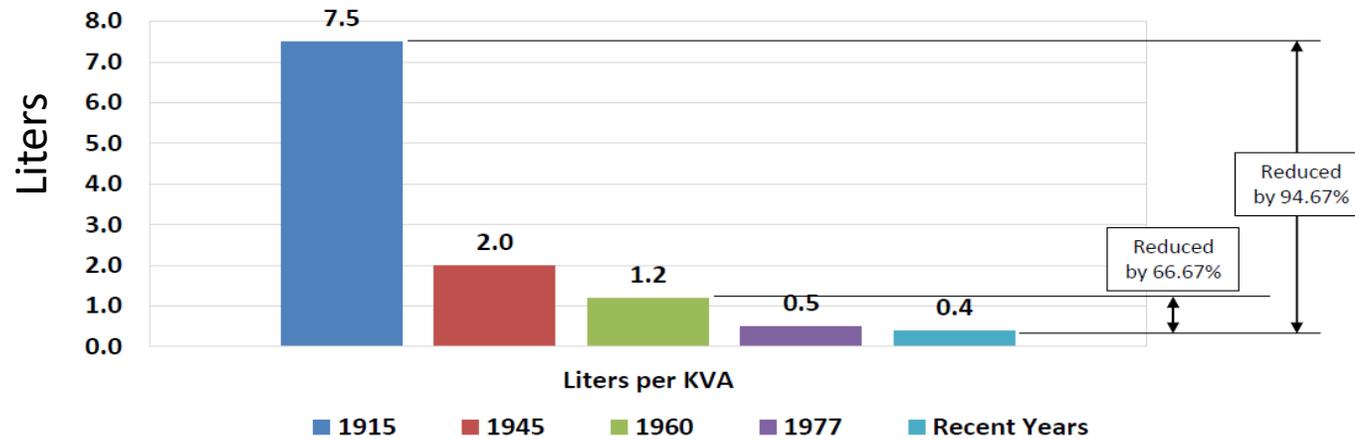
Who wants to return to the 50s?



Transformer Design Changes

- Designs are not as conservative as in the past

Quantity of Oil per kVA



Manufacturing Year	Liters per kVA
1915	7.5
1945	2.0
1960	1.2
1977	0.5
Recent years	0.4



1970s Vintage Transformer



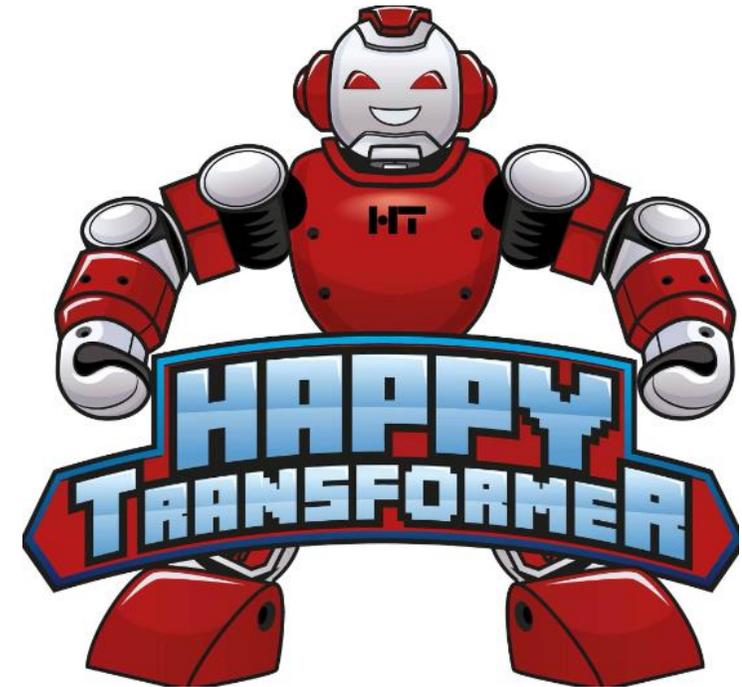
Transformer Maintenance Strategies

- 1) Do Nothing – Wait for the next emergency replacement.
- 2) Periodic insulating fluid samples
 - Good for slow progressing issues
 - Many labs have a 30-to-90-day lead time for analysis
 - One customer said the transformer failed before the lab results came back
- 3) Online Monitoring
 - Single or multi-gas DGA
 - Current/Voltage/Harmonics
 - Bushing Monitoring
 - Partial Discharge Monitoring
 - LTC Monitoring
- 4) Solution depends on criticality, health, operating history, etc.
 - Small, healthy or non-critical transformers may get Hydrogen, or a Hydrogen/Moisture monitor only
 - Critical Transformers may get a complete monitoring package



Conclusions

- Transformer life expectancy data is difficult to find. Some conclusions can be drawn from broad industry data.
- Transformers are sometimes removed from service before failure.
- Typical life expectation is between 20 and 60 years.
- Transformers will likely last a long time if:
 - They are designed well
 - They are manufactured well
 - They are maintained well
 - They have been operated within recommended guidelines
 - They have been protected from through-faults
- Your transformers may have a reduced life if any or all of these items are in question.



Thank You

Dr. Tony McGrail
tmcgrail@doble.com

Leon White, PE
lwhite@h2scan.com