Safer, Stronger, Smarter Networks

EEA Health Indicators

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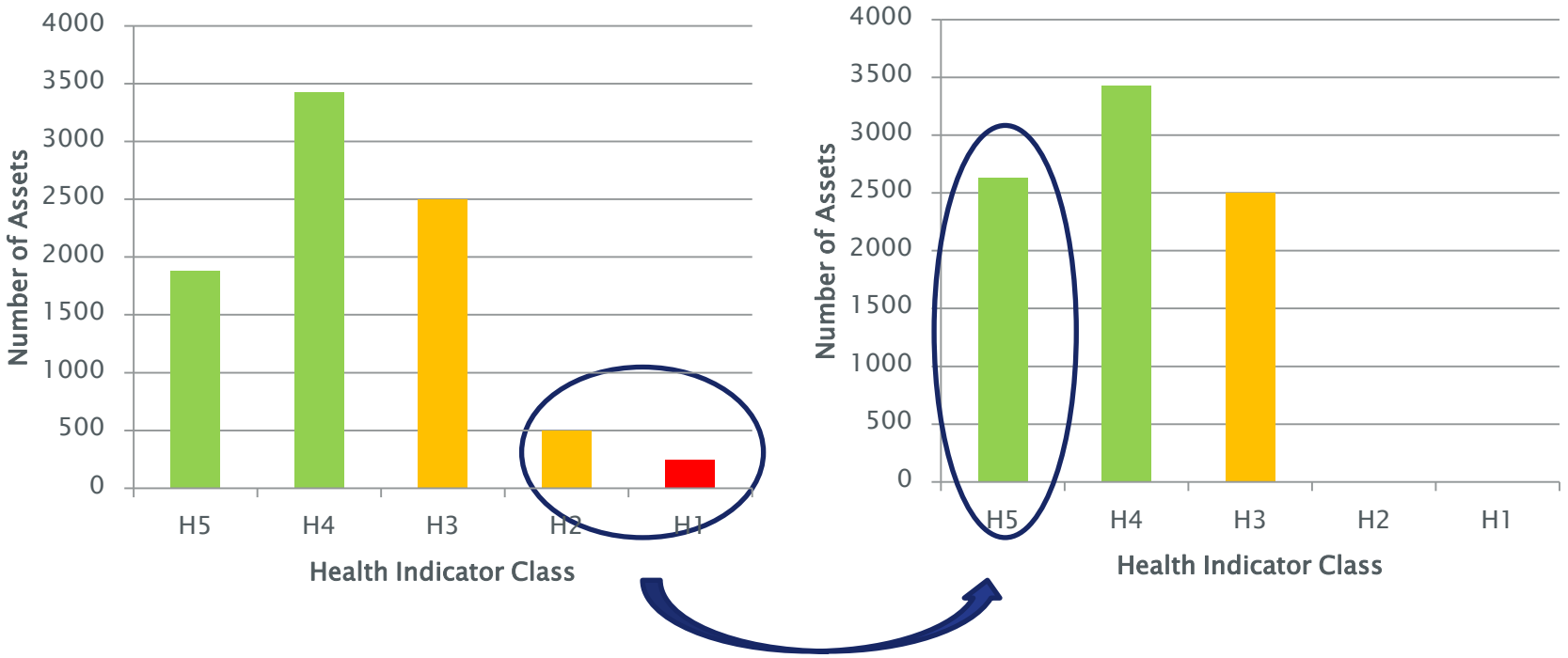
Health Indicator - Combine information from a range of sources into a single ‘number’ that represents asset fitness for service

EEA - Health Indicator Levels

H5	As new condition – no drivers for replacement.
H4	Asset serviceable – no drivers for replacement, normal in service deterioration.
H3	End of life drivers for replacement present, increasing Asset related risk.
H2	End of life drivers for replacement present, high asset related risk.
H1	Replacement recommended.

Why – Understand asset condition to drive action.

Why - Show the effect of investment on overall asset health



Attributes of a good AHI

1. Is correlated with the presence of deterioration that increases the likelihood of the asset to fail to fulfil its intended function.
2. Captures – non condition related factors that contribute to replacement decisions.
3. Makes use of readily available information sources, both quantitative and qualitative.
4. Focusses on dominant life limiting factors that affect the population (cannot cover every scenario).
5. Is logically consistent.
6. Is reflective of local, industry experience.
7. Provides a logical stepping stone to more advanced asset management practices.
8. Is simple and implementable.

Benefits

- Provide a view of assets requiring replacement and those on the threshold of requiring replacement.
- Allow us to model changes in the health indicator profile for varying levels of investment.
- Allow us to model changes in the asset health profile over time
- Assist in communicating the ‘state of the network’ to stakeholders.
- Assist with ranking and prioritising investments
- Provide a gateway for more advanced quantitative risk management approaches.

Limitations

- Is not directly related to asset probability of failure.
- Is not readily amenable to forecasting due to non-linear Yes/No fitness for purpose inputs.
- Does not provide detail necessary for quantitative risk modelling.
- Is not a substitute for good engineering judgement – a filter only.

How does it work?

End of Life Drivers (EOL Drivers)

Performance (health)

Has this asset deteriorated
To a level where the probability of failure
Is intolerably high?

Economics (cost)

Are the ongoing costs of owning/operating and/or managing the consequences of failure for this asset
Intolerably high?

Design (Requirements)

Is the fundamental design of this asset fit for purpose? Does this asset meet todays' capability requirements?
Is this asset correctly applied?

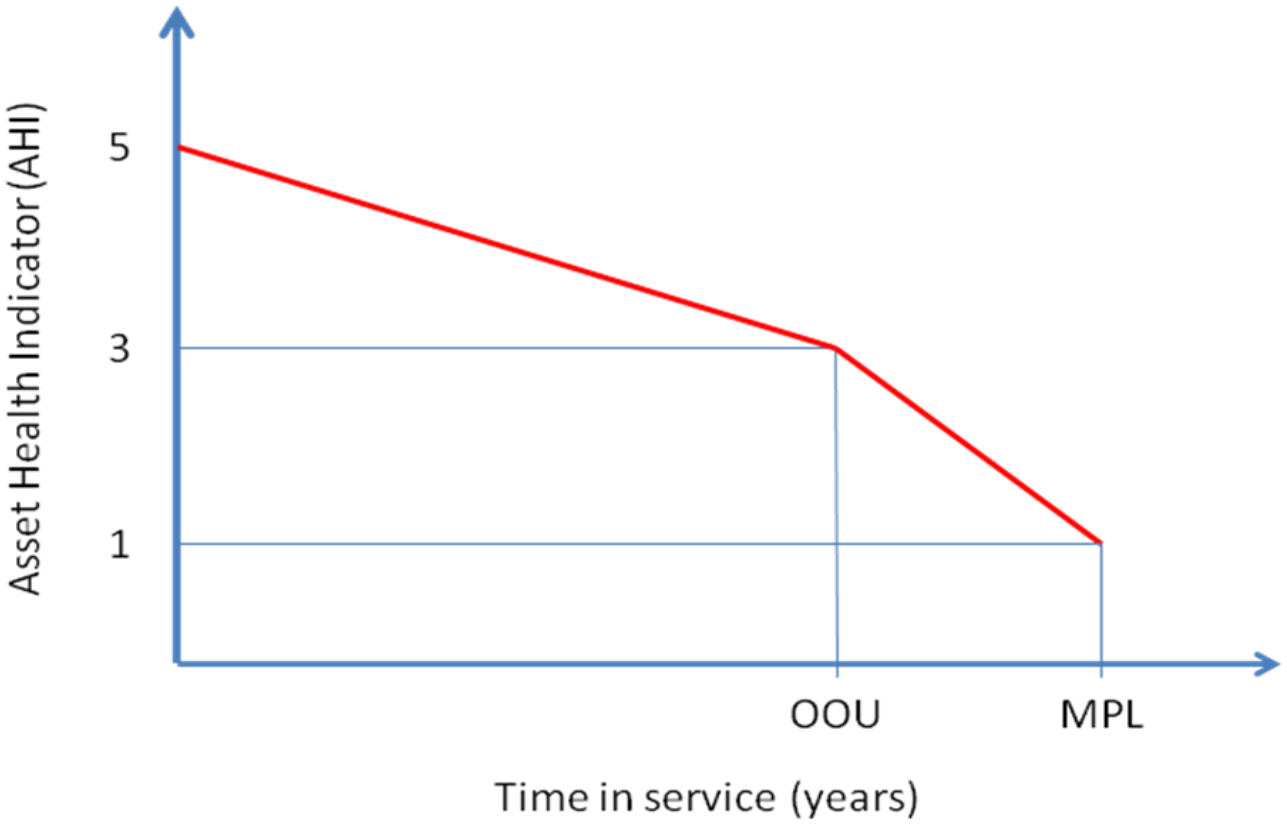
Typical inputs

	TYPICAL FACTORS
Performance (health)	Condition, Condition monitoring data, observations – age as a backup.
Economic (LCC)	Elevated consequences of failure, training not economically available, spares not available, increased losses, orphan asset types.
Design (Requirements)	Safety standards, design standards, operational requirements. Not capacity.

Determine the key End of Life Drivers and assign grading criteria

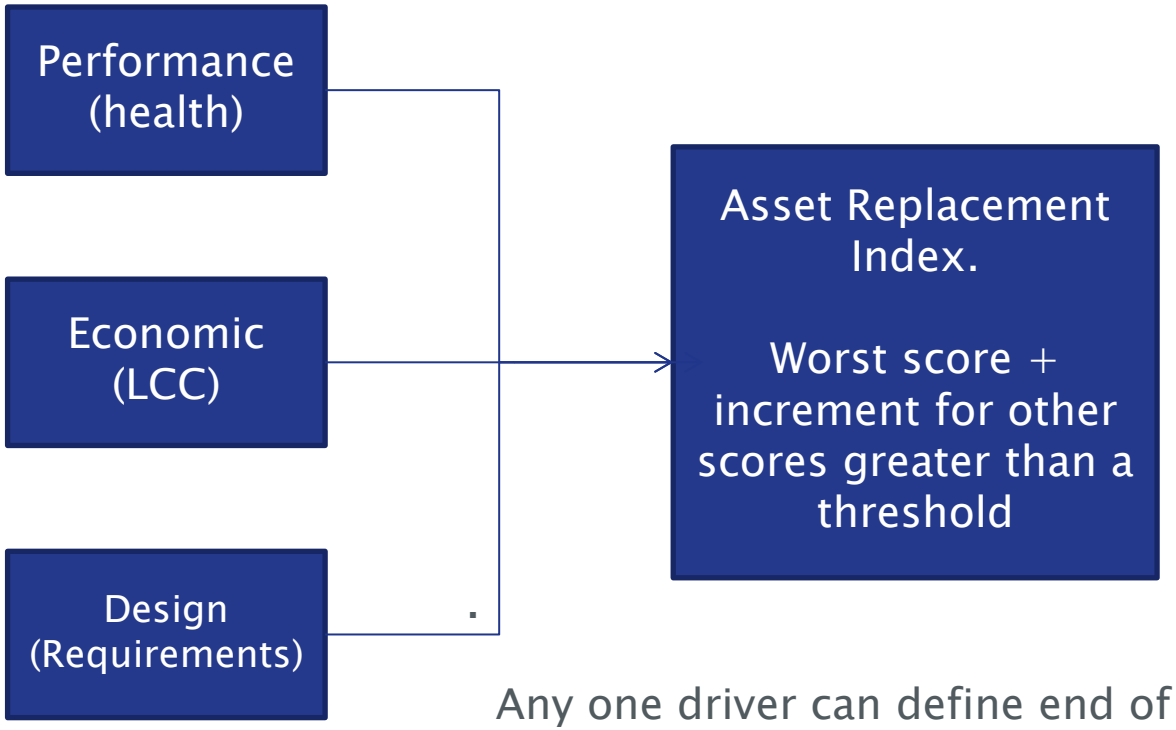
EOL Driver	H5	H4	H3	H2	H1
Paper Degree of Polymerisation (DP)	>950	950-700	700 - 500	500 - 200	<200
Tank external condition	As new condition.	Some deterioration of paintwork and/or minor repairable oil leaks. Manageable through normal maintenance.	Transformer tank, fins and ancillaries have significant corrosion or damage and/or significant oil leaks. Repairs/refurbishment practicable and cost effective.	Transformer tank, fins and ancillaries are corroded or damaged to an advanced extent. Refurbishment is either marginally or not cost effective.	Transformer tank, fins and ancillaries are corroded or damaged to an extent where repair or refurbishment is not economical and failure to exclude water or contain oil is likely.
Bushing condition	No deterioration detected.	Minor deterioration, bushing insulation diagnostics, within normal operating limits.	Bushing insulation diagnostics show some deterioration classified as fair and within serviceability limits. Increased surveillance recommended. ¶ ¶ Bushing housing may have minor chipping or burn damage. No evidence of oil or compound leaks.	Bushing insulation diagnostics show some deterioration classified as poor and near serviceability limits. Replacement recommended. ¶ ¶ Bushing housing may have significant chipping or burn damage and or evidence of oil or compound leaks.	Bushing insulation diagnostics outside of serviceability limits indicating high probability of failure. Bushings not recommended to be put back into service. Bushing porcelain may have significant chipping or burn damage and/or evidence of advanced oil or compound leaks.
Mechanical integrity of transformer cores, windings, and press frames. (Susceptibility to through faults).	SFRA traces show no anomalies — no changes in comparison to previous result.	No criteria — use H5	No criteria — use H5	SFRA traces indicate possible defect placing transformer at some risk of failure during network fault conditions.	SFRA positively indicates a serious defect placing transformer at high risk of failure during network fault conditions.

Using asset age as a health indicator input



Sub population definition	Onset of Unreliability (H3)	Maximum Practical life (H1)
Transmission and Distribution Power Transformer > 2 MVA	35	65
Generator Transformer > 2 MVA Outdoors.	35	65

A weighted score approach is not appropriate if combining differing drivers into a single index, as some inputs are highly non-linear (i.e. an asset is either fit for purpose or it is not)



Any one driver can define end of life independently of another. EOL scores in one area + poor scores In other areas will rank an asset more highly than one with an EOL score in one area alone. One good score will not null out a bad score.

Final AHI $= Lowest$ AHI

– Number of remaining $H2$ EOL factors $\times WF2$

– Number of remaining $H3$ EOL factors $\times WF3$

EOL·Score¤	Weighting·factor¤
H2¤	WF2·=·0.5¤
H3¤	WF3·=·0.1¤

Example

A power transformer has the following scores for EOL drivers

- Paper degree of polymerisation = H2
- Bushing condition = H2
- Tank external condition = H3
- Insulation system condition = H3

The final AHI score would be as follows

Final AHI = 2 – (0.5 x 1) – (0.1 x2), therefore

Final AHI = 1.3

Questions?

EOL Drivers – Power Transformers

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Paper Degree of Polymerisation (DP)	>950	950-700	700 - 500	500 - 200	<200

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Tank external condition	As new condition	Some deterioration of paintwork manageable through normal maintenance. No evidence of oil weeps or leaks.	Transformer tank and fins have significant corrosion or damage and/or oil weeps indicative of deterioration of sealing components.	Transformer tank and fins are corroded or damaged to an advanced extent and difficult to repair oil leaks are present.	Transformer tank and fins and ancillaries are corroded or damaged to an extent where repair or refurbishment is not economical and failure to exclude water or contain oil is likely.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Bushing condition	No deterioration detected.	Minor deterioration, bushing insulation diagnostics, within normal operating limits.	Bushing insulation diagnostics show some deterioration classified as fair and within serviceability limits. Increased surveillance recommended. Bushing housing may have minor chipping or burn damage. No evidence of oil or compound leaks.	Bushing insulation diagnostics show some deterioration classified as poor and near serviceability limits. Replacement recommended. Bushing housing may have significant chipping or burn damage and or evidence of oil or compound leaks.	Bushing insulation diagnostics outside of serviceability limits indicating high probability of failure. Bushings not recommended to be put back into service. Bushing porcelain may have significant chipping or burn damage and/or evidence of advanced oil or compound leaks.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Mechanical integrity of transformer cores, windings, and press frames. (Susceptibility to through faults).	SFRA traces show no anomalies – no changes in comparison to previous result.	No criteria – use H5	No criteria – use H5	SFRA traces indicate possible defect placing transformer at some risk of failure during network fault conditions.	SFRA positively indicates a serious defect placing transformer at high risk of failure during network fault conditions.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Insulation System Compromised (paper and oil)	No deterioration of insulation system detected.	Minor deterioration detected in winding insulation and/or oil quality test, (e.g. DGA, IFT, DDF, dielectric breakdown, particle count, acidity, corrosive sulphur and moisture)	Moderate deterioration detected in winding insulation and/or oil quality tests (DGA, IFT, DDF, dielectric breakdown, particle count, acidity, corrosive sulphur and moisture). Repairs/refurbishment/oil reclamation practicable and cost effective.	Significant deterioration detected in winding insulation and/or oil quality tests (IFT, DDF, dielectric breakdown, particle count, acidity, corrosive sulphur and moisture). Immediate repairs/refurbishment required. Heavy oil sludging / conductive contaminants may be present. Repair may not be cost effective.	Winding insulation and oil condition indicate severe deterioration and significantly increased probability of failure. Refurbishment or repair is not economical. Significant presence of oil sludging / conductive contaminants, to a level that compromises integrity of insulation and increases likelihood of failure.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Known type or design issues	No type or design issues.	Minor design or type issues that may reduce expected service life and/or increase operating costs.	Design or type issues present that increase likelihood of failure, but within tolerable levels.	Design or type issues present that significantly increase likelihood of failure and requiring management or design modification.	Significant design or type issues present that render the asset not fit for purpose.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Safety	Design features meet all current requirements for safety.	Design features do not meet all current safety requirements, however no additional operating precautions required.	Design features do not meet all current safety requirements, but risk may be effectively managed at acceptable cost with operational precautions.	Design features do not meet all current safety requirements and present an elevated safety risk. Hazard management causes significant operational issues and added cost.	Design features are non-compliant with statutory requirements or represent an intolerable safety hazard that cannot be effectively managed.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Availability of maintenance parts for OLTC or load tap changer.	Spare parts are readily available from the OEM.	Spare parts are readily available from aftermarket sources.	New parts are not readily available but the OLTC can be effectively maintained and repaired through use of second hand , re-manufactured components or retrofit with new OTLC.	New parts are not available but OLTC can be maintained with difficulty through use of second hand and re-manufactured components.	Parts to properly maintain and/or repair the OLTC in the event of failure are not available.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Noise	Transformer meets noise regulations.	No criteria use H5.	Transformer does not meet noise regulations but is in a location where noise issues do not impact on neighbours.	Transformer does not meet noise regulations, rectification is desirable, or may be cost effectively addressed by other means.	Transformer does not meet noise regulations, rectification is mandatory and cannot be cost effectively addressed by other means.

Power Transformer EOL Criteria

Input Factor	H5	H4	H3	H2	H1
Workforce skills	Competent resources necessary for the ongoing safe and reliable operation and/or repair of the equipment are readily available and core trade competency.	Competent resources necessary for the ongoing safe and reliable operation and/or repair of the equipment are readily available, but considered a specialist skill.	Competent resources necessary for the ongoing safe and reliable operation and/or repair of the equipment are not readily available and must be actively developed or acquired at increased cost.	Competent resources necessary for the ongoing safe and reliable operation and/or repair of the equipment are scarce and uneconomical to acquire, develop and maintain.	Competent resources necessary for the ongoing safe and reliable operation and/or repair of the equipment are not available.

Power Transformer Age Parameters

Sub population definition	Onset of Unreliability (H3)	Maximum Practical life (H1)	ODV Life (~H2)
Transmission and Distribution Power Transformer > 2 MVA	35	65	45
Generator Transformer > 2 MVA Outdoors.	35	65	45

Questions?

Afternoon Workshop

- Objective: In a team environment, review the current draft of the AHI guideline and offer improvement feedback.
- Approach:
  - Split into focus groups based on area of technical interest
    - Transformers
    - Switchgear
    - Structures
    - Cables
  - Review the section of the guideline, and report to the larger group
  - Final wrap up and next actions