User Guide to Excel Database of Demonstrative Distribution Transformers

This user guide aims to explain

1. How to read and interpret the data and results included in the demonstrative Excel database.
2. How to apply the proposed assessment strategy on individual distribution transformers in case they are not included in the demonstrative Excel database.

1. How to read and interpret demonstrative Excel database

150 distribution transformers have been randomly selected from ENW distribution transformer population, and the assessment strategy proposed in this project has been applied on these selected distribution transformers for demonstrative purpose. Results are collected and presented in the Excel database.

The Excel database has 9 sheets, which are

1. BAU Scenario: contains data and results of 150 transformers under BAU EV scenario.
2. Mapping-BAU: contains mapping of failure probability of 150 transformers under BAU EV scenario.
3. Mid-range Scenario: contains data and results of 150 transformers under Mid-range EV scenario.
4. Mapping-Mid-range: contains mapping of failure probability of 150 transformers under Mid-range EV scenario.
5. High-range Scenario: contains data and results of 150 transformers under High-range EV scenario.
6. Mapping-High-range: contains mapping of failure probability of 150 transformers under High-range EV scenario.
7. Extreme-range Scenario: contains data and results of 150 transformers under Extreme-range EV scenario.
8. Mapping-Extreme-range: contains mapping of failure probability of 150 transformers under Extreme-range EV scenario.
9. Appendix: contains definitions of EV scenarios and essential input data used for the assessment of 150 transformers.

In the “scenario” sheets, firstly, fonts with different colours are used for the header of each column, where

- Green means general information and required input data for the assessment, which should be available from the transformer operator.
- Blue means intermediate data generated by the assessment strategy.
- Red means desired ultimate results, which are loss-of-life, expected lifetime and failure probability.

In addition, in order to emphasize transformers that could be potentially failure under EV scenarios, transformers with a failure probability over 0 are highlighted by different colours, where

- Green means failure probability no larger than 50%.
- Yellow means failure probability between 50% and 99.9%.
- Red means failure probability over 99.9%.

In the "mapping" sheets, two figures are presented under each EV scenario, which are

- Geographic mapping of failure probability in ENW territory.
- Mapping of failure probability against transformer age and peak load under EV scenario.

In the mapping, transformers with different failure probability are highlighted by different colours, where

- Blue means failure probability is 0.
- Green means failure probability is greater than 0 but no larger than 50%.
- Yellow means failure probability between 50% and 99.9%.
- Red means failure probability over 99.9%.

In the "Appendix" sheet, extra essential input data (apart from those presented in "scenario" sheets) required by the strategy are presented. These data should be adjusted when the strategy is applied on other transformers (other than 150 transformers presented in the Excel database).

2. How to assess individual transformers with proposed strategy

The assessment strategy can be realized by a series of Matlab files. How to apply these files is explain here.

2.1 One-click solution – run file "Assessment.m" with Matlab

A one-click solution is provided by simply running "Assessment.m" with Matlab. Run the m-file, and it will ask for necessary input including

- EV penetration level ("PEV" in the code) – input a number between 0 and 100
- Power rating ("Rating" in the code) – input power rating of the transformer in kVA
- Age ("Age" in the code) – input transformer age
- Indoor / outdoor installation ("InOut" in the code) – input 1 for indoor; 0 for outdoor
- Customer number ("PCNo" in the code) – input an 8 element vector representing customer numbers of each profile class from PC1 to PC8.

As outputs, the failure probability ("FB" in the code), loss-of-life ("LOL" in the code) and expected lifetime ("Life" in the code) will be displayed and stored as well.

Note:

- All Matlab files including m-file and mat-file must be put in the same folder, since the "Assessment.m" needs to call other m-files.
- The repetition is set as 5000 times; therefore it may take some time to run.

2.2 Brief explanation of each file

Explanation of each file provided except for "Assessment.m" is presented below

- "LoadElexon.m": calculate load profile of a transformer with customer numbers.
- "EVcharging.m": calculate EV charging load.
- "InOutCor.m": correct ambient and top-oil rise due to indoor installation.
- "moiOil.m": estimate moisture in oil with transformer age.
- "MoilPaper.m": estimate moisture in paper.
- "BubHST.m": estimate bubbling inception temperature.

- “HSTfunctionDay.m”: calculate hot-spot temperature for failure probability estimation.
- “HSTfunction.m”: calculate hot-spot temperature for loss-of-life estimation.
- “Elexonbaseload.mat”: database containing Elexon base load for the calculation of load profile of individual distribution transformers.

2.3 Adjustable data

Due to lack of data, a few assumptions have been made on some input and intermediate data when applying the assessment strategy on the demonstrative group of distribution transformers. These data can be updated when measured or monitored data are available. More detailed explanation on this matter can be found on the report submitted with the Excel database.

Adjustable data in the Matlab files are displayed and explained below

- Elexon base load can be updated to reflect the up-to-date loading situation of ENW.
- In “BubHST.m”, the external pressure of oil at bubbling location (parameter “P” in the code) can be updated if known.
- In “InOutCor.m”, the rated top-oil rise (parameter “Thor” in the code) can be updated for the transformer to be investigated.
- In “HSTfunction.m” and “HSTfunctionday.m”, thermal parameters can be updated for the transformer to be investigated, which include “R”, “k11”, “k21”, “k22”, “Tau”, “Tau_w”, “H”, “gr”, “x” and “y”. The refinement methods of thermal parameters for individual distribution transformers are provided in the report.