Package 'CNAIM'

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Type Package

Title Common Network Asset Indices Methodology (CNAIM)

Version 1.0.0

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Description Implementation of the CNAIM standard in R. Contains a series of algorithms which determine the probability of failure, consequences of failure and monetary risk associated with electricity distribution companies' assets such as transformers and cables. Results are visualized in an easy-to-understand risk matrix.

URL https://www.cnaim.io/

BugReports https://github.com/Utiligize/CNAIM/issues

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R topics documented:

`beta_1` *Initial Ageing Rate*

Description

This function calculates the initial ageing rate for an electric network asset. See section 6.1.5 on page 32 in CNAIM (2017).

Usage

```
beta_1(expected_life_years)
```

Arguments

`expected_life_years`
: Numeric. The output returned by the function `expected_life`().

Value

Numeric. Initial ageing rate for an electric network asset.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
beta_1(expected_life_years = 10)
```

---

cof *Consequences of Failure*

Description

This function calculates consequences of failure (cf.section 7, page 71, CNAIM, 2017).

Usage

```
cof(financial_cof, safety_cof, environmental_cof, network_cof)
```

Arguments

financial_cof	Numeric. Financial consequences of failure.
safety_cof	Numeric. Safety consequences of failure.
environmental_cof	Numeric. Environmental consequences of failure.
network_cof	Numeric. Network cost of failure.

Value

Numeric. Consequences of failure.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

`cof_transformer_11kv` *Consequences of Failure for a 6.6/11 kV transformer*

Description

This function calculates consequences of failure for a 6.6/11 kV transformer (cf.section 7, page 71, CNAIM, 2017).

Usage

```
cof_transformer_11kv(
  kva,
  type,
  type_risk,
  location_risk,
  prox_water,
  bunded,
  no_customers,
  kva_per_customer
)
```

Arguments

`kva`	Numeric. The rated transformer capacity measured in kVA for a 6.6/11 kV transformer. Rated capacity is used to derive the type financial factor. For a general description of type financial factor see section 7.3.3.1 on page 76 in CNAIM (2017). A setting of `"Default"` will result in a type financial factor equal to 1 (cf. section D1.2.1, page 162, CNAIM, 2017).
`type`	String. Relates to the accessibility of the transformer Options: `type = c("Type A","Type B","Type C","Default")`. A setting of `"Type A"` - Normal access. A setting of `"Type B"` - Constrained access or confined working space. A setting of `"Type C"` - Underground substation. A setting of `"Default"` - Normal access thus same as `"Type A"` setting (cf. table 214, page 164, CNAIM, 2017).
`type_risk`	String. Risk that the asset presents to the public by its characteristics and particular situation. Options: `type_risk = c("Low","Medium","High","Default")` (cf. table 218, page 168, CNAIM, 2017). A setting of `"Default"` equals a setting of `"Medium"`.
`location_risk`	String. Proximity to areas that may affect its likelihood of trespass or interference. Options: `location_risk = c("Low","Medium","High","Default")` (cf. table 218, page 168, CNAIM, 2017). A setting of `"Default"` equals a setting of `"Medium"`.
`prox_water`	Numeric. Specify the proximity to a water course in meters. A setting of `"Default"` will result in a proximity factor of 1. Thus assume the proximity to a water course is between 80m and 120m (cf. table 223, page 172, CNAIM, 2017).

bunded — String. Options: bunded = c("Yes","No","Default"). A setting of "Default" will result in a bunding factor of 1.

no_customers — Numeric. The numner of customers fed by an individual asset.

kva_per_customer — Numeric. If the asset have an exceptionally high demand per customer type in kVA per customer. A setting of "Default" results in a multiplication factor of 1 (cf. table 18, page 86, CNAIM, 2017).

Value

Numeric. Consequences of failure for a 6.6/11 kV transformer.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# Consequences of failure for a 6.6/11 kV transformer
cof_transformer_11kv(kva = 500, type = "Type C",
                     type_risk = "High", location_risk = "High",
                     prox_water = 50, bunded = "No",
                     no_customers = 500, kva_per_customer = 1)
```

---

current_health *Current Health score*

Description

This function calculates the current health score for a given electric network asset (cf. CNAIM, 2017. Page 21, section 4.3.2).

Usage

```
current_health(
  initial_health_score,
  health_score_factor,
  health_score_cap = "Default",
  health_score_collar = "Default",
  reliability_factor = "Default"
)
```

Arguments

`initial_health_score`
: Numeric. The output from the function `initial_health()`.

`health_score_factor`
: Numeric. E.g. output from the function `health_score_excl_ehv_132kv_tf()`.

`health_score_cap`
: Numeric. Specifies the maximum value of current health score. The cap is used in situations where a good result from a condition inspection or measurement implies that the health score should be no more than the specified value. The cap is derived as the minimum of the observed condition cap and the measured condition cap. Measured and observed condition caps are found in lookup tables depending in the asset category, when determine the observed and measured condition factors. A setting of `"Default"` sets the `health_score_cap` to 10.

`health_score_collar`
: Numeric. Specifies the minimum value of Current Health Score. The collar is used in situations where a poor result from a condition inspection or measurement implies that the health score should be at least the specified value. The collar is derived as the minimum of the observed condition collar and the measured condition collar. Measured and observed condition collars are found in lookup tables depending in the asset category, when determine the observed and measured condition factors. A setting of `"Default"` sets the `health_score_collar` to 0.5.

`reliability_factor`
: Numeric. `reliability_factor` shall have a value between 0.6 and 1.5. A setting of `"Default"` sets the `reliability_factor` to 1. See section 6.14 on page 69 in CNAIM (2017).

Value

Numeric. The Current health score.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
current_health(initial_health_score = 0.5,
               health_score_factor = 0.33,
               health_score_cap = 10,
               health_score_collar = 0.5,
               reliability_factor = 1)
```

duty_factor_transformer_11kv *Duty Factor for a 6.6/11 kV Transformer*

Description

This function calculates the duty factor for a 6.6/11 kV transformer depending on the maximum percentage utilisation under normal operating conditions. The duty factor is used in the deriviation of the expected life of an asset. See e.g. `expected_life()`. For more general information about the derivation of the duty factor see section 6.6 on page 47 in CNAIM (2017)

Usage

```
duty_factor_transformer_11kv(utilisation_pct = "Default")
```

Arguments

`utilisation_pct`
: Numeric. The max percentage of utilisation under normal operating conditions for a 6.6/11 kV transformer.

Value

Numeric. Duty factor for a 6.6/11 kV transformer.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
duty_factor_transformer_11kv(utilisation_pct = 95)
```

expected_life *Expected Life*

Description

This function calculates the expected life of an electric network asset measured in years when it would be expected to first observe significant deterioration. The expected life is derived based on the assets normal expected life, duty factor and location factor. See section 6.1.4 on page 32 in CNAIM (2017).

Usage

```
expected_life(normal_expected_life, duty_factor, location_factor)
```

Arguments

normal_expected_life	Numeric. The number of years a new asset is expected to normally last. I.e. technical life time. See page 103, table 20 in CNAIM (2017).
duty_factor	Numeric. E.g. the output returned by the function duty_factor_transformer_11kv().
location_factor	Numeric. The output returned by the function location_factor().

Value

Numeric. Expected life.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# An asset e.g. a transformer with an expcted life of 50 years
expected_life(normal_expected_life = 50,
              duty_factor = 1,
              location_factor = 1)
```

---

e_cof_tf *Environmental Consequences of Failure for transformers*

Description

This function calculates environmental consequences of failure for all type of transformers. (cf. section 7.5, page 80, CNAIM, 2017). Environmental consequences of failure is used in the derivation of consequences of failure see cof().

Usage

```
e_cof_tf(
  asset_type_tf,
  rated_capacity = "Default",
  prox_water = "Default",
  bunded = "Default"
)
```

Arguments

asset_type_tf	String. Transformer types. Options: asset_type_tf = c("6.6/11kV Transformer (GM)","20kV Transformer (GM)","33kV Transformer (GM)","66kV Transformer (GM)","132kV Transformer (GM)").
rated_capacity	Numeric. The rated capacity for a transformer. For type "6.6/11kV Transformer (GM)" and "20kV Transformer (GM)" use kVA ratings. For "20kV Transformer (GM)","33kV Transformer (GM)","66kV Transformer (GM)","132kV Transformer (GM)" use MVA ratings. A setting of "Default" will result in a size environmental factor of 1 (cf. table 222, page 171, CNAIM, 2017).
prox_water	Numeric. Specify the proximity to a water course in meters. A setting of "Default" will result in a proximity factor of 1. Thus assume the proximity to a water course is between 80m and 120m (cf. table 223, page 172, CNAIM, 2017).
bunded	String. Options: bunded = c("Yes","No","Default"). A setting of "Default" will result in a bunding factor of 1.

Value

Numeric. Financial cost of failure for a 10kV transformer.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# Environmental consequences of failure for a 6.6/11 kV transformer
e_cof_tf(asset_type_tf = "6.6/11kV Transformer (GM)",
rated_capacity = 750, prox_water = 100, bunded = "Yes")
```

---

f_cof_transformer_11kv

Financial Consequences of Failure for a 6.6/11 kV Transformer

---

Description

This function calculates financial consequences of failure (cf. section 7.3, page 75, CNAIM, 2017). Financial consequences of failure is used in the derivation of consequences of failure see cof().

Usage

```
f_cof_transformer_11kv(kva = "Default", type = "Default")
```

Arguments

kva	Numeric. The rated transformer capacity measured in kVA for a 6.6/11 kV transformer. Rated capacity is used to derive the type financial factor. For a general description of type financial factor see section 7.3.3.1 on page 76 in CNAIM (2017). A setting of "Default" will result in a type financial factor equal to 1 (cf. section D1.2.1, page 162, CNAIM, 2017).
type	String. Relates to the accessibility of the transformer Options: type = c("Type A","Type B","Type C","Default"). A setting of "Type A" - Normal access. A setting of "Type B" - Constrained access or confined working space. A setting of "Type C" - Underground substation. A setting of "Default" - Normal access thus same as "Type A" setting (cf. table 214, page 164, CNAIM, 2017).

Value

Numeric. Financial consequences of failure for a 6.6/11 kV transformer.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# Financial consequences of failure for a 6.6/11 kV transformer
f_cof_transformer_11kv(kva = 700, type = "Default")
```

---

health_score_excl_ehv_132kv_tf

Health Score Factor for all Assets Categories excl. EHV and 132kV Transformers

---

Description

This function calculates the health score factor for all asset categories exclusive the assets EHV and 132kV transformers. For EHV and 132kV transformers see mmi(). The function combines observed and measured condition factors using the simplified maximum and multiple increment (MMI) technique to construct the health score factor (cf. CNAIM, 2017, page 52, table 9).

Usage

```
health_score_excl_ehv_132kv_tf(
  observed_condition_factor,
  measured_condition_factor
)
```

Arguments

observed_condition_factor
: Numeric.

measured_condition_factor
: Numeric.

Value

Numeric. Health score factor.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# An asset with an observed condition factor of 1 and a measured condition
# factor of 0.33
 health_score_excl_ehv_132kv_tf(observed_condition_factor = 1,
 measured_condition_factor = 0.33)
```

---

initial_health *Initial Health*

Description

Calculating the initial health score for a given asset. See section 6.1.6 on page 32 in CNAIM (2017).

Usage

```
initial_health(b1, age)
```

Arguments

b1	Numeric. The output returned by the function beta_1().
age	Numeric. The crurrent age of the asset.

Value

Numeric. Initial health for an electric network asset.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# 6.6/ 11 kv transformer age 10 years and an initial age rate of 0.05
initial_health(b1 = 0.05,
               age = 10)
```

`location_factor` *Location Factor*

Description

This function calculates the location factor for an electric network asset based in the specific location of the asset. See section 6.4 on page 4 in CNAIM (2017).

Usage

```
location_factor(
  placement = "Default",
  altitude_m = "Default",
  distance_from_coast_km = "Default",
  corrosion_category_index = "Default",
  asset_type = "6.6/11kV Transformer (GM)"
)
```

Arguments

`placement`	String. Specify if the asset is located outdoor or indoor. A setting of `"Outdoor"` means the asset is located in an outside environment, and a setting of `"Indoor"` means the asset is located in an indoor environment. A setting of `"Default"` will result in either an indoor or an outdoor environment setting that depends on the specification of `asset_type`. See page 107-108, table 25A in CNAIM (2017) for default environments.
`altitude_m`	Numeric. Specify the altitude location for the asset measured in meters from sea level.`altitude_m` is used to derive the altitude factor. See page 107, table 23 in CNAIM (2017). A setting of `"Default"` will set the altitude factor to 1 independent of `asset_type`.
`distance_from_coast_km`	Numeric. Specify the distance from the coast measured in kilometers. `distance_from_coast_km` is used to derive the distance from coast factor See page 106, table 22 in CNAIM (2017). A setting of `"Default"` will set the distance from coast factor to 1 independent of `asset_type`.
`corrosion_category_index`	Integer. Specify the corrosion index category, 1-5. `corrosion_category_index` is used to derive the corrosion category factor. See page 107, table 24 in CNAIM (2017). A setting of `"Default"` will set the corrosion category factor to 1 independent of `asset_type`.

asset_type — String. A sting that refers to the specific asset category. See See page 15, table 1 in CNAIM (2017). Options: asset_type = c("LV Poles","LV Circuit Breaker","LV Pillar (ID)","LV Pillar (OD at Substation)","LV Pillar (OD not at a Substation)","LV Board (WM)","LV UGB","LV Board (X-type Network) (WM)","6.6/11kV Poles","20kV Poles","HV Sub Cable","6.6/11kV CB (GM) Primary","6.6/11kV CB (GM) Secondary","6.6/11kV Switch (GM)","6.6/11kV RMU","6.6/11kV X-type RMU","20kV CB (GM) Primary","20kV CB (GM) Secondary","20kV Switch (GM)","20kV RMU","6.6/11kV Transformer (GM)","20kV Transformer (GM)","33kV Pole","66kV Pole","33kV OHL (Tower Line) Conductor","33kV Tower","33kV Fittings","66kV OHL (Tower Line) Conductor","66kV Tower","66kV Fittings","33kV UG Cable (Non Pressurised)","33kV UG Cable (Oil)","33kV UG Cable (Gas)","66kV UG Cable (Non Pressurised)","66kV UG Cable (Oil)","66kV UG Cable (Gas)","EHV Sub Cable","33kV CB (Air Insulated Busbars)(ID) (GM)","33kV CB (Air Insulated Busbars)(OD) (GM)","33kV CB (Gas Insulated Busbars)(ID) (GM)","33kV CB (Gas Insulated Busbars)(OD) (GM)","33kV Switch (GM)","33kV RMU","66kV CB (Air Insulated Busbars)(ID) (GM)","66kV CB (Air Insulated Busbars)(OD) (GM)","66kV CB (Gas Insulated Busbars)(ID) (GM)","66kV CB (Gas Insulated Busbars)(OD) (GM)","33kV Transformer (GM)","66kV Transformer (GM)","132kV OHL (Tower Line) Conductor","132kV Tower","132kV Fittings","132kV UG Cable (Non Pressurised)","132kV UG Cable (Oil)","132kV UG Cable (Gas)","132kV Sub Cable","132kV CB (Air Insulated Busbars)(ID) (GM)","132kV CB (Air Insulated Busbars)(OD) (GM)","132kV CB (Gas Insulated Busbars)(ID) (GM)","132kV CB (Gas Insulated Busbars)(OD) (GM)","132kV Transformer (GM)")

Value

Numeric. Location factor

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
 # Location factor for a 6.6/11 kV Transformer with default values
location_factor(placement = "Default", altitude_m = "Default",
distance_from_coast_km = "Default",
corrosion_category_index = "Default",
asset_type = "6.6/11kV Transformer (GM)")
```

---

matrix_adjusted_circles

Adjust circles for matrix visualization

Description

This function manipulates the data structure before inputting into javascript D3 risk matrix visualization

Usage

```
matrix_adjusted_circles(risk_data_matrix, dots_vector, dot_radius)
```

Arguments

risk_data_matrix	Long format matrix data.
dots_vector	Coordinates of the dots.
dot_radius	Radius of the dots.

Value

Long format matrix data. circles for D3 matrix visualization adjusted

---

matrix_adjusted_intervals

Adjust banding for matrix visualization

Description

This function manipulates the data structure before inputting into javascript D3 risk matrix visualization

Usage

```
matrix_adjusted_intervals(risk_data_matrix, x_intervals, y_intervals)
```

Arguments

risk_data_matrix	Long format matrix data.
x_intervals	An array of x spacing in percent (sum to 100)
y_intervals	An array of y spacing in percent (sum to 100)

Value

Long format matrix data. intervals for matrix D3 visualization adjusted

mmi *Maximum and Multiple Increment (MMI) Technique*

Description

This function returns a combined factor using a maximum and multiple increment (MMI) technique (cf. CNAIM, 2017. page 50, section 6.7.2). The function can be used to derive the health score factor for EHV and 132kV transformers. For deriviation of the health score factor for all other assets see `health_score_excl_ehv_132kv_tf`. To derive the health score factor for EHV and 132kV transformers one needs to use `mmi()` to derive the health score factor for the main transformer and for the tapchanger respectively. The constants `factor_divider_1`, `factor_divider_2` and `max_no_combined_factors` are all available in the lookup table 10 and 11 on page 53 and 54 in CNAIM (2017). For an in deph desciption see also section 6.8 on page 53 in CNAIM (2017). The `mmi()` can also be used in the derivation of observed and measured condition factors for all assets, using measured and observed input factors. The constants `factor_divider_1`, `factor_divider_2` and `max_no_combined_factors` can be found in table 13 on page 59 (observed condition factors) and in table 15 on page 63 (measured condition factors).

Usage

```
mmi(factors, factor_divider_1, factor_divider_2, max_no_combined_factors)
```

Arguments

`factors`	Numeric vector. Factors to me combined.
`factor_divider_1`	Numeric. Constant that specifies the degree to which additional "good" or "bad" factors are able further drive the combined factor.
`factor_divider_2`	Numeric. Constant that specifies the degree to which additional "good" or "bad" factors are able further drive the combined factor.
`max_no_combined_factors`	Numeric. Specifies how many factors are able to simultaneously affect the combined factor.

Value

Numeric. Combined factor.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
mmi(factors = c(1,
1.5),
factor_divider_1 = 1.5,
factor_divider_2 = 1.5,
max_no_combined_factors = 1)
```

`n_cof_excl_ehv_132kv_tf` *Network cost of Failure for all Assets Categories excl. EHV and 132kV Transformers*

Description

This function calculates network cost of failure for all asset categories exclusive the assets EHV and 132kV transformers. (cf. section 7.6, page 83, CNAIM, 2017). Network cost of failure is used in the derivation of consequences of failure see `cof`().

Usage

```
n_cof_excl_ehv_132kv_tf(
  asset_type_ncf,
  no_customers,
  kva_per_customer = "Default"
)
```

Arguments

`asset_type_ncf`	String. `asset_type_ncf = c("LV Poles","LV Circuit Breaker","LV Pillar (ID)","LV Pillar (OD at Substation)","LV Pillar (OD not at a Substation)","LV Board (WM)","LV UGB","LV Board (X-type Network) (WM)","6.6/11kV Poles","20kV Poles","HV Sub Cable","6.6/11kV CB (GM) Primary","6.6/11kV CB (GM) Secondary","6.6/11kV Switch (GM)","6.6/11kV RMU","6.6/11kV X-type RMU","20kV CB (GM) Primary","20kV CB (GM) Secondary","20kV Switch (GM)","20kV RMU","6.6/11kV Transformer (GM)","20kV Transformer (GM)","33kV Pole","66kV Pole","33kV OHL (Tower Line) Conductor","33kV Tower","33kV Fittings","66kV OHL (Tower Line) Conductor","66kV Tower","66kV Fittings","33kV UG Cable (Non Pressurised)","33kV UG Cable (Oil)","33kV UG Cable (Gas)","66kV UG Cable (Non Pressurised)","66kV UG Cable (Oil)","66kV UG Cable (Gas)","33kV CB (Air Insulated Busbars)(ID) (GM)","33kV CB (Air Insulated Busbars)(OD) (GM)","33kV CB (Gas Insulated Busbars)(ID) (GM)","33kV CB (Gas Insulated Busbars)(OD) (GM)","33kV Switch (GM)","33kV RMU","66kV CB (Air Insulated Busbars)(ID) (GM)","66kV CB (Air Insulated Busbars)(OD) (GM)","66kV CB (Gas Insulated Busbars)(ID) (GM)","66kV CB (Gas Insulated Busbars)(OD) (GM)","33kV Transformer (GM)","66kV Transformer (GM)")`
`no_customers`	Numeric. The numner of customers fed by an individual asset.

kva_per_customer
: Numeric. If the asset have an exceptionally high demand per customer type in kVA per customer. A setting of "Default" results in a multiplication factor of 1 (cf. table 18, page 86, CNAIM, 2017).

Value

Numeric. Network cost of failure.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# Network cost of failure for a 6.6/11 kV transformer with 750 customers
# and 51 kVA per customer.
n_cof_excl_ehv_132kv_tf(asset_type_ncf = "6.6/11kV Transformer (GM)",
no_customers = 750, kva_per_customer = 51)
```

---

pof_future_transformer_11kv

Future Probability of Failure for a 6.6/11 kV Transformer

Description

This function calculates the future annual probability of failure for a 6.6/11 kV transformer. The function is a cubic curve that is based on the first three terms of the Taylor series for an exponential function. For more information about the probability of failure function see section 6 on page 30 in CNAIM (2017).

Usage

```
pof_future_transformer_11kv(
  utilisation_pct = "Default",
  placement = "Default",
  altitude_m = "Default",
  distance_from_coast_km = "Default",
  corrosion_category_index = "Default",
  age,
  partial_discharge = "Default",
  oil_acidity = "Default",
  temperature_reading = "Default",
  observed_condition = "Default",
  reliability_factor = "Default",
  simulation_end_year = 100
)
```

Arguments

`utilisation_pct`
: Numeric. The max percentage of utilisation under normal operating conditions for a 6.6/11 kV transformer.

`placement`
: String. Specify if the asset is located outdoor or indoor. A setting of `"Outdoor"` means the asset is located in an outside environment, and a setting of `"Indoor"` means the asset is located in an indoor environment. A setting of `"Default"` will result in either an indoor or an outdoor environment setting that depends on the specification of `asset_type`. See page 107-108, table 25A in CNAIM (2017) for default environments.

`altitude_m`
: Numeric. Specify the altitude location for the asset measured in meters from sea level.`altitude_m` is used to derive the altitude factor. See page 107, table 23 in CNAIM (2017). A setting of `"Default"` will set the altitude factor to 1 independent of `asset_type`.

`distance_from_coast_km`
: Numeric. Specify the distance from the coast measured in kilometers. `distance_from_coast_km` is used to derive the distance from coast factor See page 106, table 22 in CNAIM (2017). A setting of `"Default"` will set the distance from coast factor to 1 independent of `asset_type`.

`corrosion_category_index`
: Integer. Specify the corrosion index category, 1-5. `corrosion_category_index` is used to derive the corrosion category factor. See page 107, table 24 in CNAIM (2017). A setting of `"Default"` will set the corrosion category factor to 1 independent of `asset_type`.

`age`
: Numeric. The current age in years of the 10-kV transformer.

`partial_discharge`
: String. Indicating the level of partial discharge. Options for `partial_discharge`: `partial_discharge = c("Low","Medium","High (Not Confirmed)","High (Confirmed)","Defaul`
See page 138, table 159 in CNAIM (2017).

`oil_acidity`
: Numeric. Measured in mg KOH/g. See page 138, table 160 in CNAIM (2017).

`temperature_reading`
: String. Indicating the criticality. Options for `temperature_reading`: `temperature_reading = c("Normal","Moderately High","Very High","Default")`. See page 139, table 161 in CNAIM (2017).

`observed_condition`
: String. Indicating the observed condition of the 10-kV transformer. Options for `observed_condition`: `observed_condition = c("As New","Good","Slight Deterioration","Poor","Very Poor","Default")`. See page 120, table 73 in CNAIM (2017).

`reliability_factor`
: Numeric. `reliability_factor` shall have a value between 0.6 and 1.5. A setting of `"Default"` sets the `reliability_factor` to 1. See section 6.14 on page 69 in CNAIM (2017).

`simulation_end_year`
: Numeric. The last year of simulating probability of failure. Default is 100.

Value

Numeric array. Future probability of failure per annum for a 6.6/11 kV transformer.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

---

`pof_transformer_11kv` *Current Probability of Failure for a 6.6/11 kV Transformer*

Description

This function calculates the current annual probability of failure for a 6.6/11 kV transformer. The function is a cubic curve that is based on the first three terms of the Taylor series for an exponential function. For more information about the probability of failure function see section 6 on page 30 in CNAIM (2017).

Usage

```
pof_transformer_11kv(
  utilisation_pct = "Default",
  placement = "Default",
  altitude_m = "Default",
  distance_from_coast_km = "Default",
  corrosion_category_index = "Default",
  age,
  partial_discharge = "Default",
  oil_acidity = "Default",
  temperature_reading = "Default",
  observed_condition = "Default",
  reliability_factor = "Default"
)
```

Arguments

`utilisation_pct`
: Numeric. The max percentage of utilisation under normal operating conditions for a 6.6/11 kV transformer.

`placement`
: String. Specify if the asset is located outdoor or indoor. A setting of `"Outdoor"` means the asset is located in an outside environment, and a setting of `"Indoor"` means the asset is located in an indoor environment. A setting of `"Default"` will result in either an indoor or an outdoor environment setting that depends on the specification of `asset_type`. See page 107-108, table 25A in CNAIM (2017) for default environments.

`altitude_m` Numeric. Specify the altitude location for the asset measured in meters from sea level.`altitude_m` is used to derive the altitude factor. See page 107, table 23 in CNAIM (2017). A setting of `"Default"` will set the altitude factor to 1 independent of `asset_type`.

`distance_from_coast_km`
Numeric. Specify the distance from the coast measured in kilometers. `distance_from_coast_km` is used to derive the distance from coast factor See page 106, table 22 in CNAIM (2017). A setting of `"Default"` will set the distance from coast factor to 1 independent of `asset_type`.

`corrosion_category_index`
Integer. Specify the corrosion index category, 1-5. `corrosion_category_index` is used to derive the corrosion category factor. See page 107, table 24 in CNAIM (2017). A setting of `"Default"` will set the corrosion category factor to 1 independent of `asset_type`.

`age` Numeric. The current age in years of the 10-kV transformer.

`partial_discharge`
String. Indicating the level of partial discharge. Options for `partial_discharge`: `partial_discharge = c("Low","Medium","High (Not Confirmed)","High (Confirmed)","Defaul`
See page 138, table 159 in CNAIM (2017).

`oil_acidity` Numeric. Measured in mg KOH/g. See page 138, table 160 in CNAIM (2017).

`temperature_reading`
String. Indicating the criticality. Options for `temperature_reading`: `temperature_reading = c("Normal","Moderately High","Very High","Default")`. See page 139, table 161 in CNAIM (2017).

`observed_condition`
String. Indicating the observed condition of the 10-kV transformer. Options for `observed_condition`: `observed_condition = c("As New","Good","Slight Deterioration","Poor","Very Poor","Default")`. See page 120, table 73 in CNAIM (2017).

`reliability_factor`
Numeric. `reliability_factor` shall have a value between 0.6 and 1.5. A setting of `"Default"` sets the `reliability_factor` to 1. See section 6.14 on page 69 in CNAIM (2017).

Value

Numeric. Current probability of failure per annum for a 6.6/11 kV transformer.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# Current probability of failure for a 6.6/11 kV transformer
pof_transformer_11kv(utilisation_pct = "Default",
```

```
placement = "Default",
altitude_m = "Default",
distance_from_coast_km = "Default",
corrosion_category_index = "Default",
age = 10,
partial_discharge = "Default",
oil_acidity = "Default",
temperature_reading = "Default",
observed_condition = "Default",
reliability_factor = "Default")
```

`risk_calculation` *Calculates risk and converts to matrix coordinates*

Description

This function calculates monetary risk, given probability of failure and consequence of failure inputs, as well as the desired risk matrix dimensions.

Usage

```
risk_calculation(matrix_dimensions, id, pof, cof, asset_type)
```

Arguments

`matrix_dimensions`	A data frame with the dimensions of the desired risk matrix
`id`	A string that describes the asset
`pof`	The probability of failure of the asset
`cof`	The consequences of failure of the asset
`asset_type`	The asset type to be calculated for class

`risk_matrix_points_plot`
Make a risk matrix with individual asset points

Description

This function makes a D3 visualization of monetary risk with each asset as a point on the grid.

Usage

```
risk_matrix_points_plot(risk_data_matrix, dots_vector, dot_radius)
```

Arguments

risk_data_matrix	Long format matrix data.
dots_vector	Coordinates of the dots.
dot_radius	Radius of the dots.

---

risk_matrix_structure *Makes a default risk matrix structure*

Description

This function makes a simple matrix structure that can be used as an input to the risk_matrix_points and risk_matrix_summary functions

Usage

```
risk_matrix_structure(cols, rows, value = NA)
```

Arguments

cols	Number of columns
rows	Number of rows
value	Default value of each cell

---

risk_matrix_summary_plot *Make a risk matrix with non-linear spacing*

Description

This function makes a D3 visualization of monetary risk with non-linear x and y intervals.

Usage

```
risk_matrix_summary_plot(
  risk_data_matrix,
  x_intervals = rep(20, 5),
  y_intervals = rep(25, 4)
)
```

Arguments

risk_data_matrix	Long format matrix data.
x_intervals	An array of x spacing in percent (sum to 100)
y_intervals	An array of y spacing in percent (sum to 100)

s_cof_swg_tf_ohl *Safety Consequences of Failure for Switchgears, Transformers & Overhead Lines*

Description

This function calculates safety consequences of failure for switchgear, transformers and overhead lines (cf. section 7.4, page 75, CNAIM, 2017). Safety consequences of failure is used in the derivation of consequences of failure see `cof()`.

Usage

```
s_cof_swg_tf_ohl(
  type_risk = "Default",
  location_risk = "Default",
  asset_type_scf
)
```

Arguments

type_risk	String. Risk that the asset presents to the public by its characteristics and particular situation. Options: type_risk = c("Low","Medium","High","Default") (cf. table 218, page 168, CNAIM, 2017). A setting of "Default" equals a setting of "Medium".
location_risk	String. Proximity to areas that may affect its likelihood of trespass or interference. Options: location_risk = c("Low","Medium","High","Default") (cf. table 218, page 168, CNAIM, 2017). A setting of "Default" equals a setting of "Medium".
asset_type_scf	String. Options: asset_type_scf = c("LV Poles","LV Circuit Breaker","LV Pillar (ID)","LV Pillar (OD at Substation)","LV Pillar (OD not at a Substation)","LV Board (WM)","LV UGB","LV Board (X-type Network) (WM)","6.6/11kV Poles","20kV Poles","6.6/11kV CB (GM) Primary","6.6/11kV CB (GM) Secondary","6.6/11kV Switch (GM)","6.6/11kV RMU","6.6/11kV X-type RMU","20kV CB (GM) Primary","20kV CB (GM) Secondary","20kV Switch (GM)","20kV RMU","6.6/11kV Transformer (GM)","20kV Transformer (GM)","33kV Pole","66kV Pole","33kV OHL (Tower Line) Conductor","33kV Tower","33kV Fittings","66kV OHL (Tower Line) Conductor","66kV Tower","66kV Fittings","33kV CB (Air Insulated Busbars)(ID) (GM)","33kV CB (Air Insulated Busbars)(OD) (GM)","33kV CB (Gas Insulated Busbars)(ID) (GM)","33kV CB (Gas Insulated Busbars)(OD) (GM)","33kV Switch (GM)","33kV RMU","66kV CB (Air Insulated Busbars)(ID) (GM)","66kV CB (Air Insulated Busbars)(OD) (GM)","66kV CB (Gas Insulated Busbars)(ID) (GM)","66kV CB (Gas Insulated Busbars)(OD) (GM)","33kV Transformer (GM)","66kV Transformer (GM)","132kV OHL (Tower Line) Conductor","132kV Tower","132kV Fittings","132kV CB (Air Insulated Busbars)(ID) (GM)","132kV CB (Air Insulated Busbars)(OD) (GM)","132kV CB (Gas Insulated Busbars)(ID) (GM)","132kV CB (Gas Insulated Busbars)(OD) (GM)","132kV Transformer (GM)")

Value

Numeric. Safety consequences of failure for switchgear, transformers and overhead lines.

Source

DNO Common Network Asset Indices Methodology (CNAIM), Health & Criticality - Version 1.1, 2017: https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

Examples

```
# Safety consequences failure for a 6.6/11 kV transformer
s_cof_swg_tf_ohl(type_risk = "Default", location_risk = "Default",
                 asset_type_scf = "6.6/11kV Transformer (GM)")
```

---

transformer_11kv_faults

Failure statistics dataset for 10,000 6.6/11kV transformers

Description

A dataset containing failure statistics for 10,000 6.6/11kV transformers from the CNAIM standard, simulated over 100 years. The variables are as follows:

Usage

```
transformer_11kv_faults
```

Format

A data frame with 103,848 rows and 13 variables:

utilisation_pct Utilization of a transformer in %

placement Is the transformer placed indoors or outdoors?

altitude_m Altitude above sea level (m)

distance_from_coast_km Distance from salt water (km)

corrosion_category_index Corrosion zone the asset exists in

partial_discharge Condition converted from TEV %-measurement

oil_acidity Oil acidity (mg KOH/g)

temperature_reading Temperature condition band

observed_condition Observed condition band

age Age of transformer (years)

pof Probability of failure (current and future) when the transformer failed

transformer_id Id of transformer that died

dead Monte carlo result showing if the transformer has died (TRUE)

Source

https://www.cnaim.io/

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