# Generation and Transmission Asset Analytics:

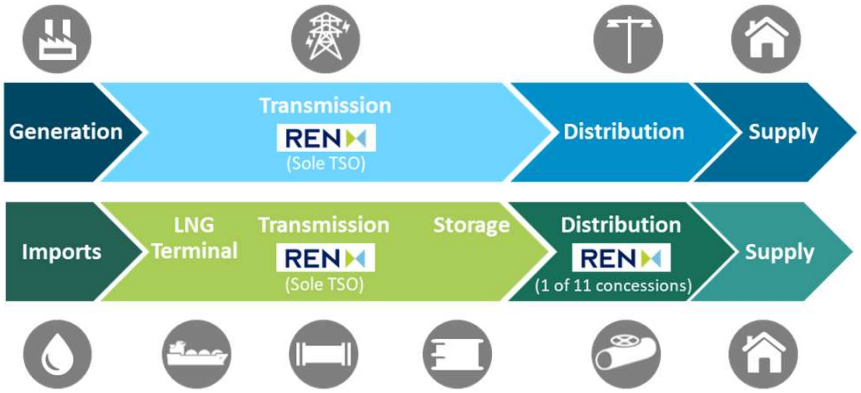
## *Separate Companies, Common Challenges*

Miguel Moreira da Silva, PhD
Head of Data & Analytics

REN
Redes Energéticas Nacionais

# 1. REN at a Glance

## REN in the Energy Value Chain

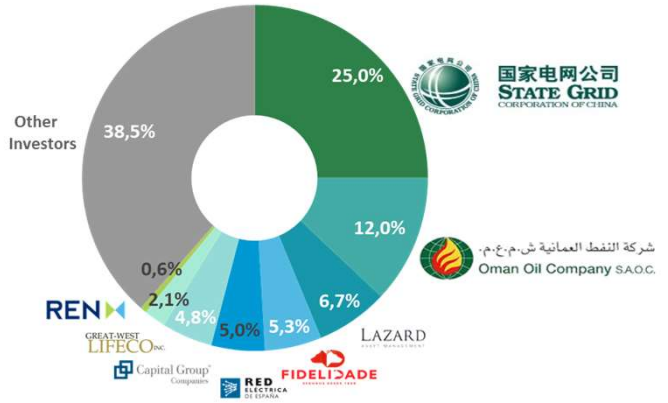



- Sole TSO for E&NG
- Average $RAB_{2016}$ = €3,537M
- 3-year regulatory period
- OPEX: revenue cap with efficiency factors
- CAPEX: return on capital (efficiency metrics through reference costs) and economic rationalization index

## National Transmission Grid - Electricity


| TECHNICAL INDICATORS | 2017 |
|---|---|
| Demand (TWh) | 49.6 |
| Annual variaton in electricity load (%) | 0.7 |
| Installed capacity (MW) | 19,800 |
| Power transmitted on the NTG (TWh) | 47.2 |
| Length of lines (km) | 8,907 |
| Transformer capacity (MVA) | 37,382 |
| Energy transmission losses (%) | 1.49 |

## Shareholders




## Key regulatory stakeholders

### Ministry for Economy

GOVERNO DE PORTUGAL

- **Setting the energy policies** and their implementation

### DGEG

Direção-Geral de Energia e Geologia

- In charge of the **design, promotion and evaluation of policies on energy** and geological resources

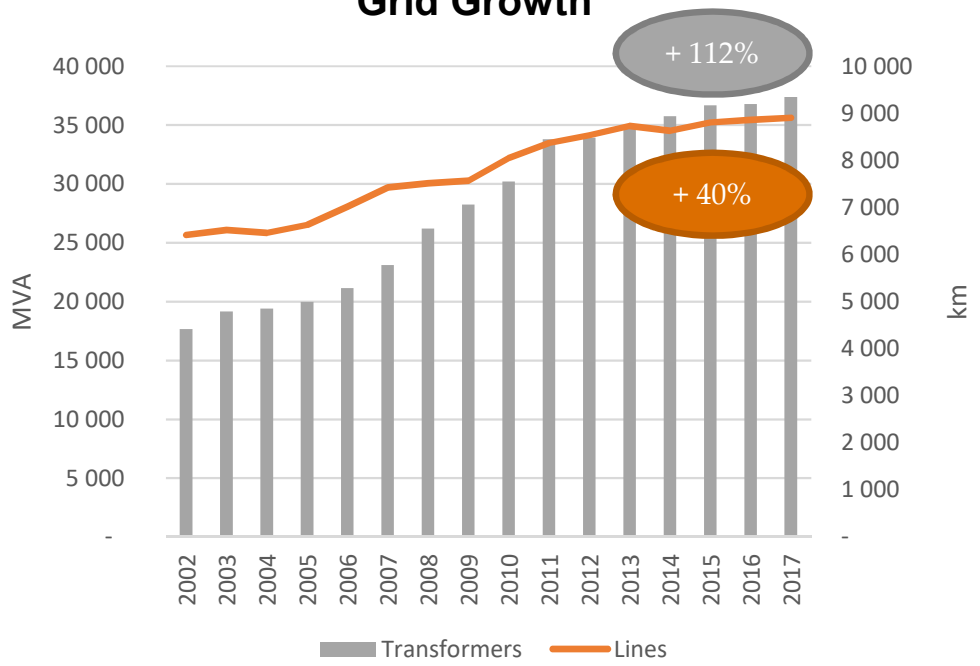
### ERSE

ERSE
ENTIDADE REGULADORA DOS SERVIÇOS ENERGÉTICOS

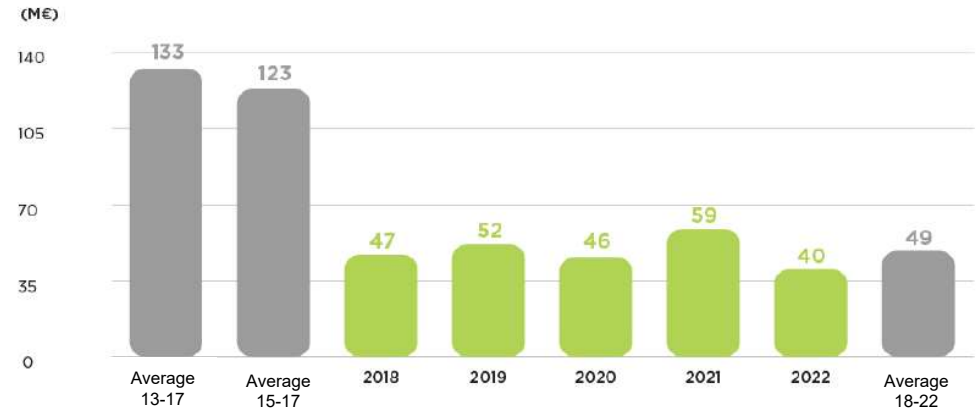
- **Independent regulatory authority** for electricity and natural gas services

# 2. Business Evolution

## Grid Growth



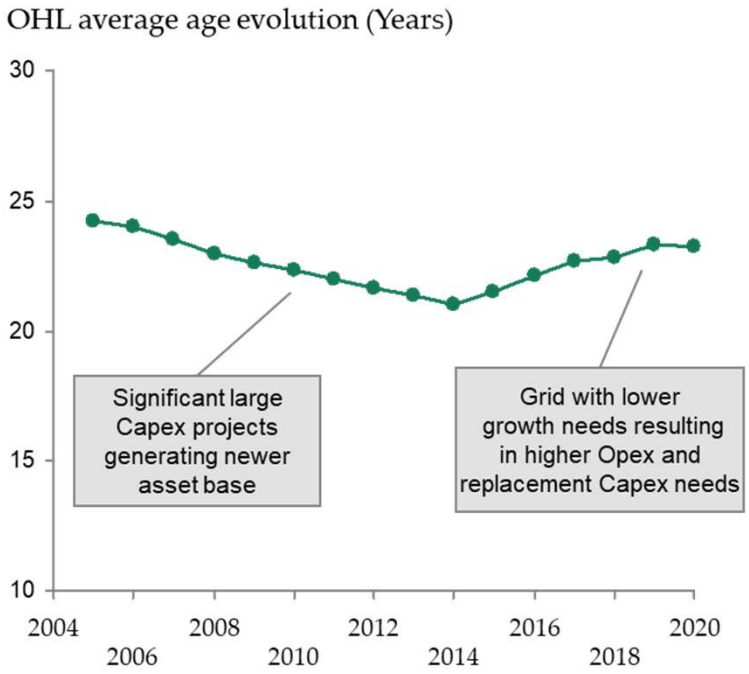

## CAPEX Plan (TYNDP)




## Key Drivers

Asset Management

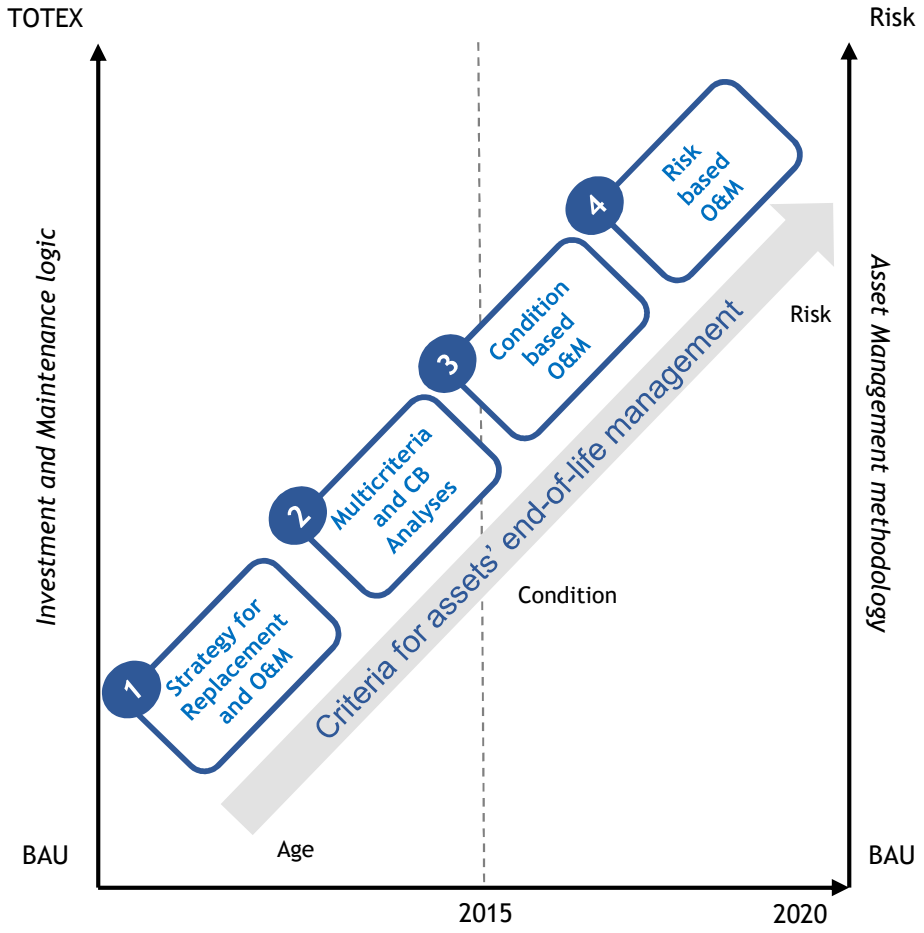
Performance



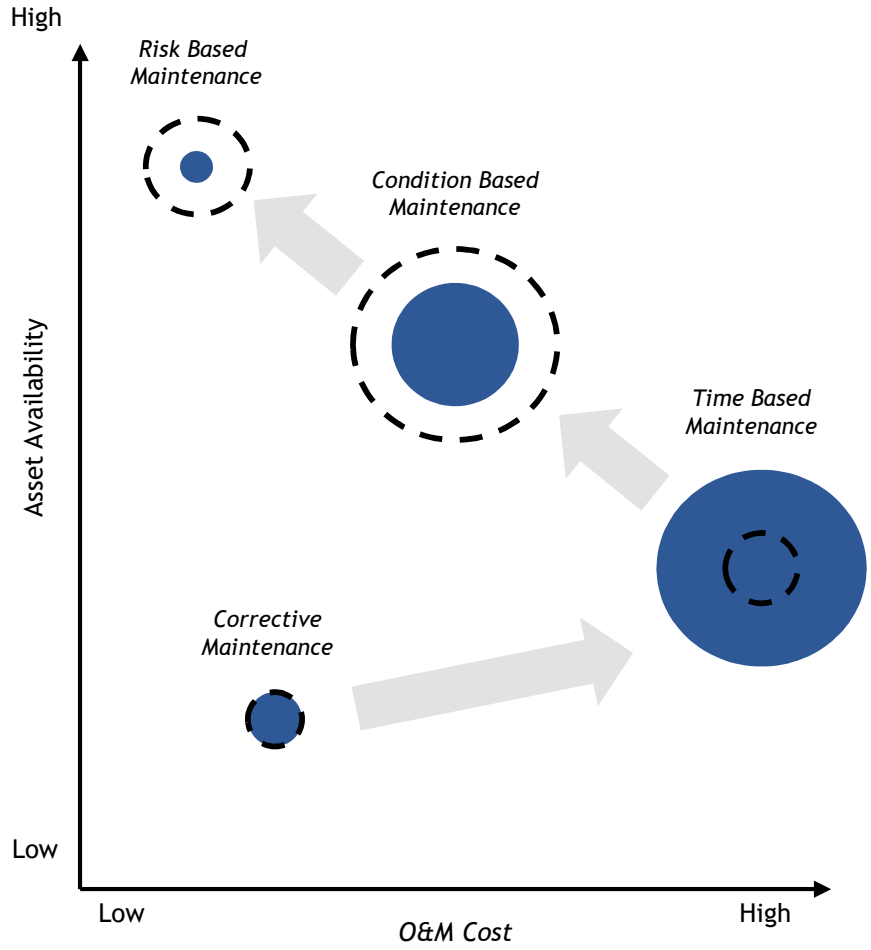
# 3. Asset Management Transformation

## Vision

### Asset Management Roadmap




### Operational Strategy



# 3. Asset Management Transformation

## Data-centric TSO

| Key Drivers | Major Impact |
| --- | --- |
| 1 Infrastructure ageing + grid incidents | *Provide probability of failure and criticality indexes to support maintenance prioritization* |
| 2 Comply with the regulatory model, focused on OPEX efficiency and remuneration partially derived from performance metrics | *Adjust frequency of maintenance based on risk and optimize M&R actions* |
| 3 Spread of databases and applications across different units, worsened by the advent of IoT/BigData | *Single dashboard and data repository for historical O&M, grid incidents, GIS and risk indexes* |

**Data Analytics is key to ensure REN is prepared to the new business context**

# 3. Asset Management Transformation

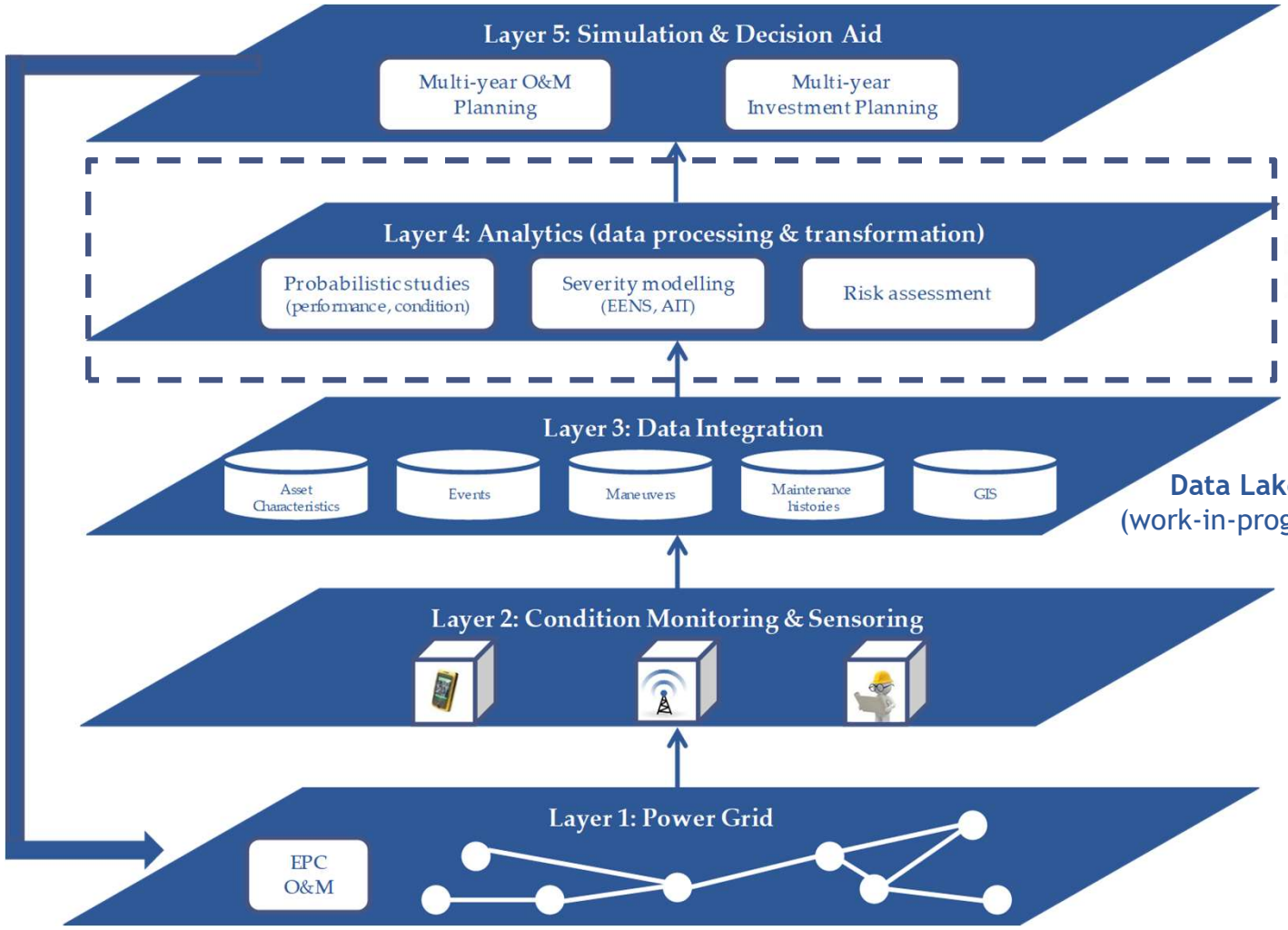
## Data-centric TSO

Vendor Outsourcing

Internal Data Science

Open-source +

+ Off-the-shelf




SMART

Developed by REN

Data Lake
(work-in-progress)

hadoop

# 4. Analytics for OHL

Developed by REN

SCADA
- Power Measurements

PSS®E
- SoS, PQ

GIS
- Geog. Inf.

SAP-PM
- Asset and O&M data

JOBS - Meteorage
- Lightning location & current

Weather Institute
- Fire Index

Gestinc
- Grid Incidents

python

SMART'L

Qlik

PostgreSQL

Historic incidents


Geographical Visualization

Risk Analysis

Asset Fragility

Vegetation

Storks

Fog/Pollution

Lightning

Wildfires

Failure Probability

Criticality

Environment

System Operation

Safety

# 4. Analytics for OHL

Developed by REN

## Circuit-based Approach

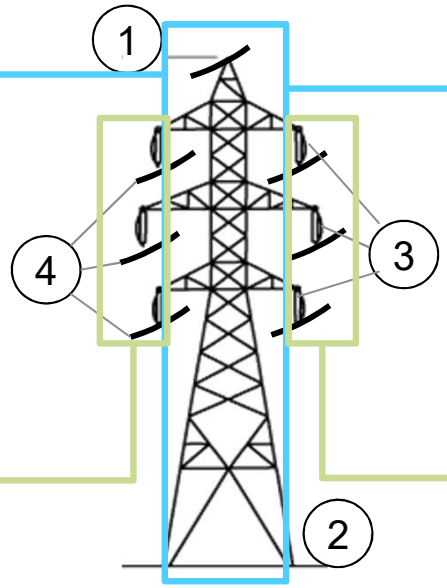
1st iteration

**Segments - 490**

1. **Ground Wire**
2. **Tower**

**Circuits - 288**

3. **Insulator chain**
4. **Conductor Cable**




## Atomic Approach

2nd iteration

**Support - 19.337**

1. **Ground Wire**
2. **Tower**

**Span - 26.738**

3. **Insulator chain**
4. **Conductor Cable**

- Mature and generally applied
- Lack of visibility of granular data of each circuit
- O&M plan based on time and worst-case scenario
- Deterministic budgeting

- Condition and risk based maintenance
- Atomic planning of O&M actions, per span and support
- Probabilistic budgeting
- Costs optimization

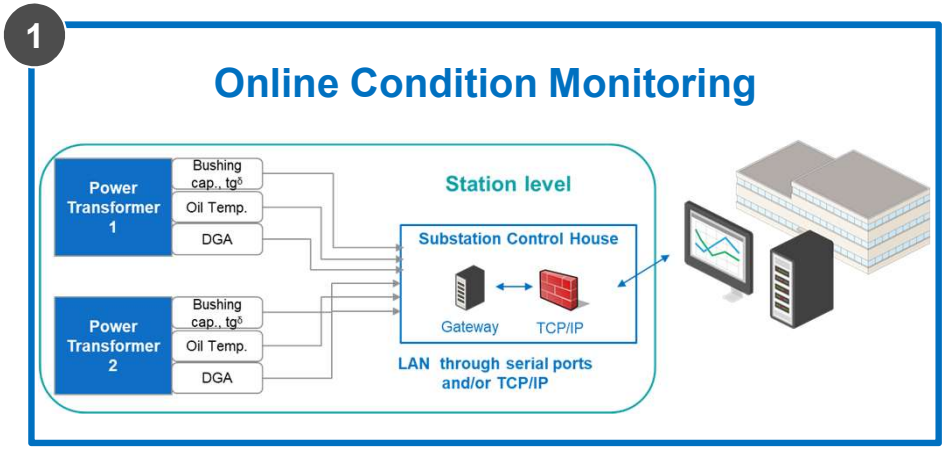
# 5. Analytics for Power Transformers

## Fragility Index - Methodology

Developed by REN

1. *Business case for PT online monitoring*
2. *Collect variables from the corresponding data sources*
3. *Atributes calculation*
4. *"Best guess" from an internal expert*
5. *Apply the most appropriate learning algorithm*

1

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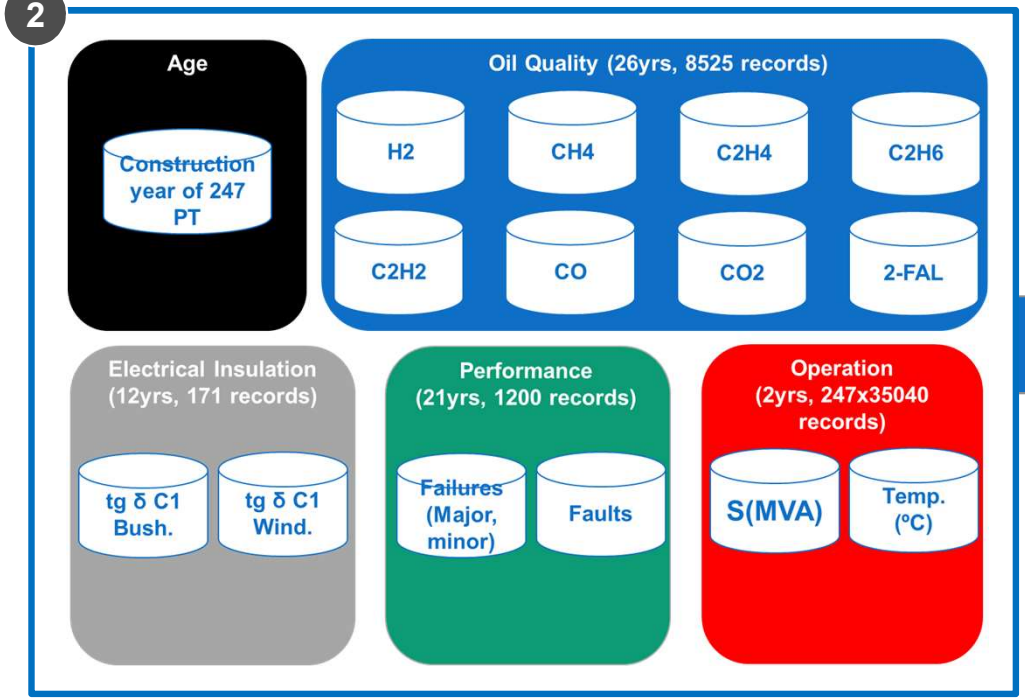


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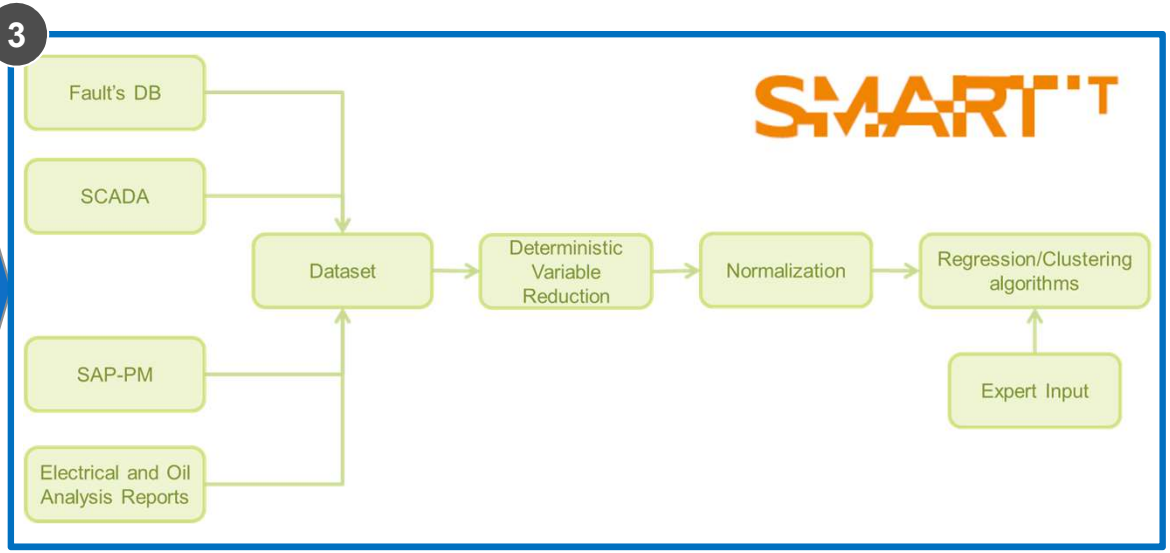


# 5. Analytics for Power Transformers

## Fragility Index - Methodology

Developed by REN

### Training Set

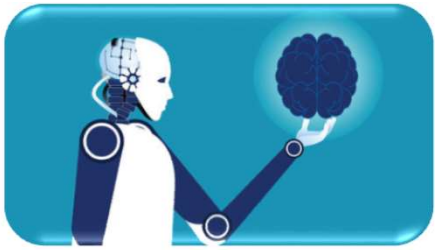
| Index | F | C |
|---|---|---|
| 45 | 2.90136 | 3.06506 |
| 46 | 2.90136 | 3.06506 |
| 47 | 2.7362 | 3.21783 |
| 48 | 2.58569 | 3.39776 |
| 49 | 2.51069 | 3.41902 |
| 50 | 1.9838 | 4.30233 |
| 51 | 2.48964 | 3.4225 |
| 52 | 2.70273 | 3.15095 |

Learn

SMART'T

Learning

Algorithms

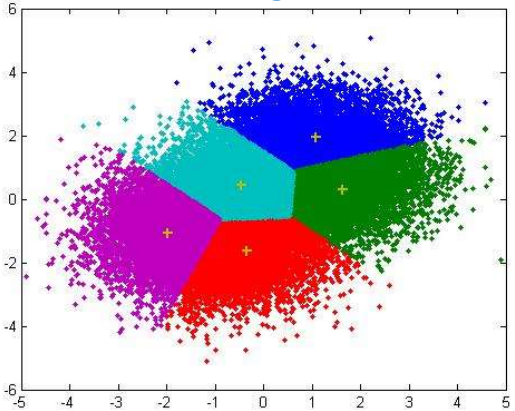


### Test Set

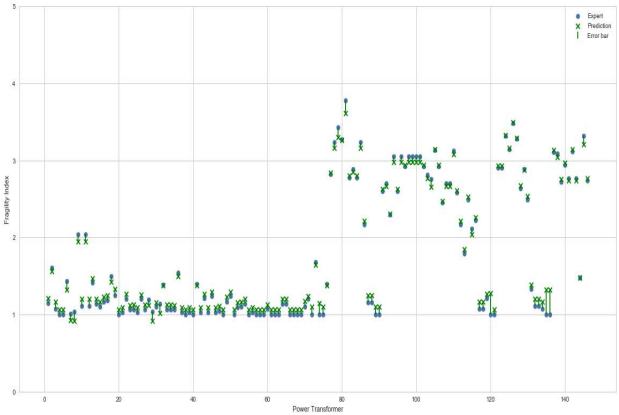
| Index | F | C |
|---|---|---|
| 0 | 3.09835 | 4.0535 |
| 1 | 3.78179 | 3.31866 |
| 2 | 3.70478 | 3.35057 |
| 3 | 3.43053 | 3.54646 |
| 4 | 3.23179 | 3.69866 |
| 5 | 3.56478 | 3.35055 |
| 6 | 3.48812 | 3.33498 |
| 7 | 3.44179 | 3.31866 |
| 8 | 3.43179 | 3.31866 |
| 9 | 2.79835 | 4.05357 |
| 10 | 3.2843 | 3.39777 |
| 11 | 3.27669 | 3.31866 |
| 12 | 3.23179 | 3.31866 |
| 13 | 3.48136 | 3.06506 |

Apply

### Clustering Model




### Regression Model



# 6. Conclusions

## Data-centric Asset Management

- In early 2017 REN has set up a dedicated team to handle BigData, Modelling and Reporting
- REN has strengthen its focus on applications governance, data quality and granularity, as well as automated ETL
- REN's Data & Analytics team has been providing deep analytics and stochastic tools, road to risk-based investment and maintenance and asset life-cycle analysis

## The case of OHL and PT

- Predictive maintenance models for OHL and PT require a systematic methodology, including a data dictionary (to get a single asset ID), automated data collection, state of art of mathematical techniques, updated ERP and GIS (data quality & quantity) and granularity (weak data sets may jeopardize the tool's credibility)
- Project team should bring together engineering and data science competences
- O&M and AM divisions should be embedded in the SW development, for expert judgement
- Manage company's expectations (these are "just" decision aid models)

# SMART

Developed by REN

**Miguel Moreira da Silva**
**miguel.silva@ren.pt**