Predictive maintenance & Asset Risk Model

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Reliability Engineer (Asset Management Onshore)

Introduction

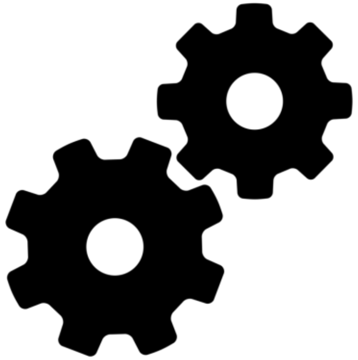
- Dr. Swasti Khuntia
- TenneT T.S.O.
- Reliability Engineer within Asset management
- I bridge the gap between data science team and maintenance engineers (both theory and practical)

- Ing. Boris Ros M.Sc.
- TenneT T.S.O.
- Reliability Engineer within Asset management
- I help TenneT to use data become more valuable so the data can work for use.

Asset Risk Model

Agenda

Motivation behind the tool



Working principle and data needs

Result interpretation and dashboard

Motivation

Ageing of assets causes
replacement wave

Combined replacements on location

Current risk method is **not location specific**

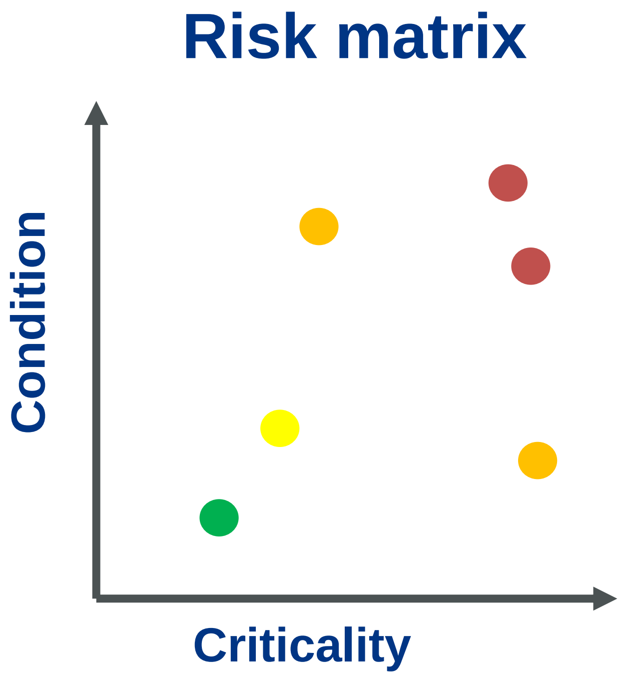
Realization capacity is too small

Increasing importance of **prioritization**

New risk method
- ✓ location specific
- ✓ data driven
- ✓ value based

Better choices!
- ✓ replacement strategy
- ✓ maintenance planning

Working principle
Theory behind the tool



Risk = *probability* **X** *effect*

= *condition* **X** *criticality*

Condition = Health Index

Criticality = importance of asset

= *effect* **X** *probability that failure leads to effect*

Working principle
Criticality

1. Potential **failure effects** were taken from existing FMECA*s

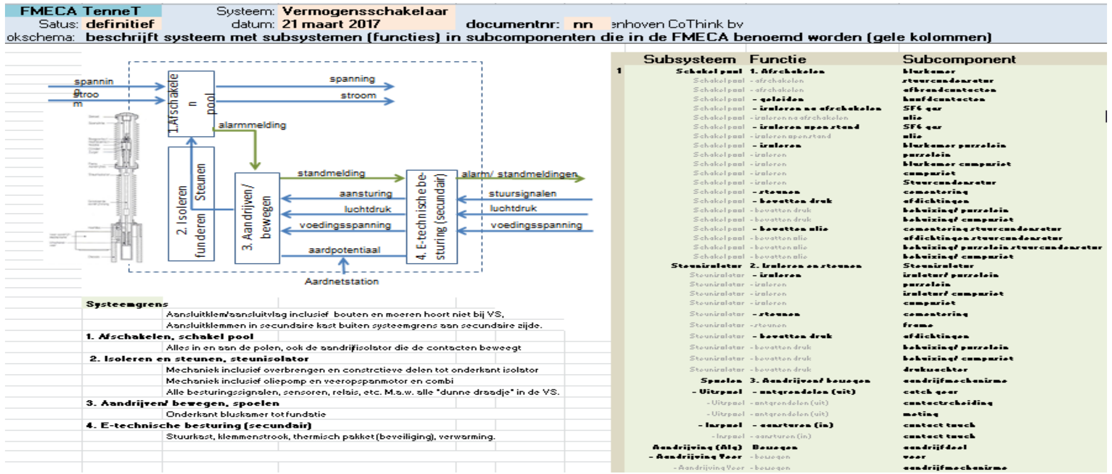
   20+ object types

2. **Effects** were scored on TenneT risk matrix

   safety, secure supply,
   environment, financial, stakeholders

3. Conditional probability that failure leads to effects was assessed

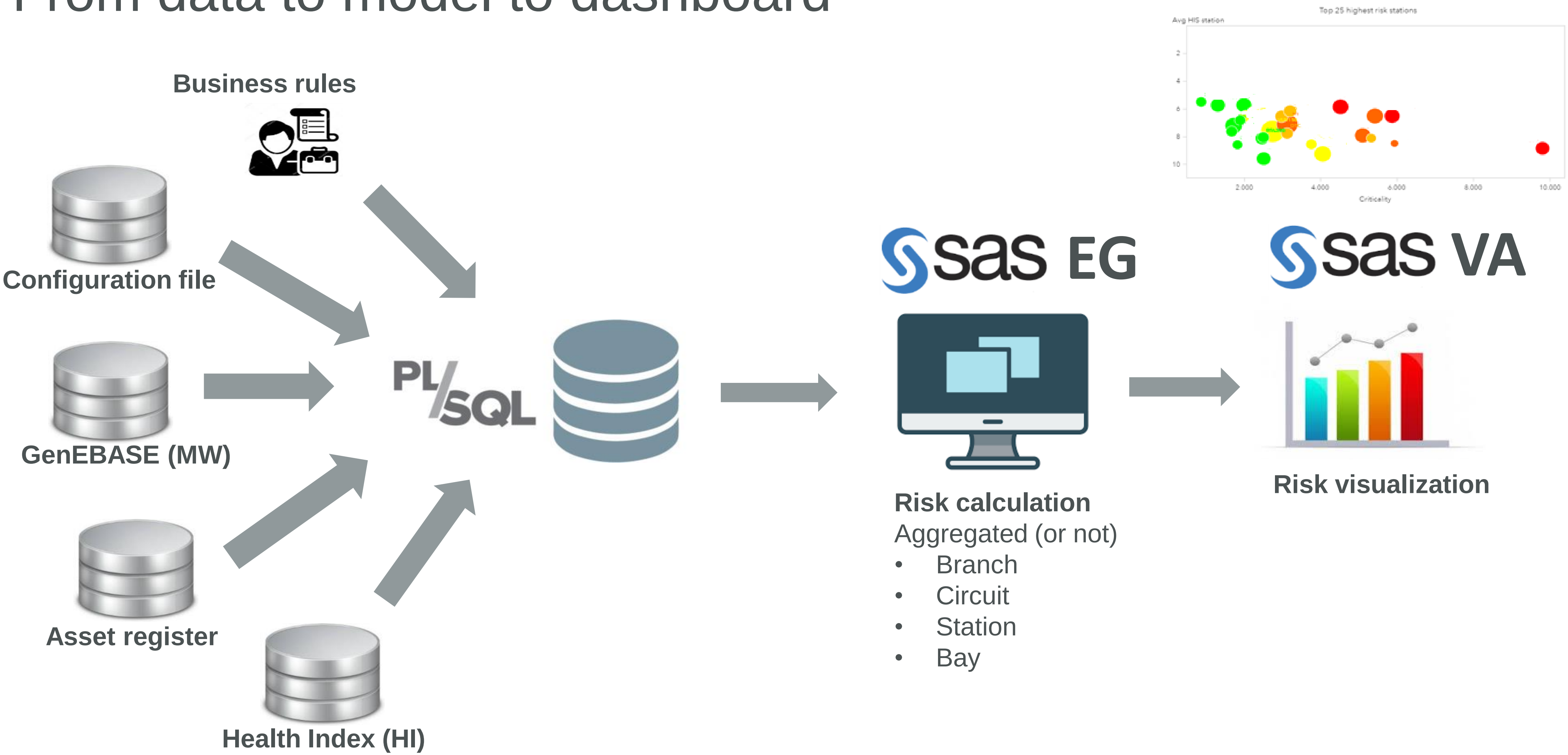
Asset Criticality



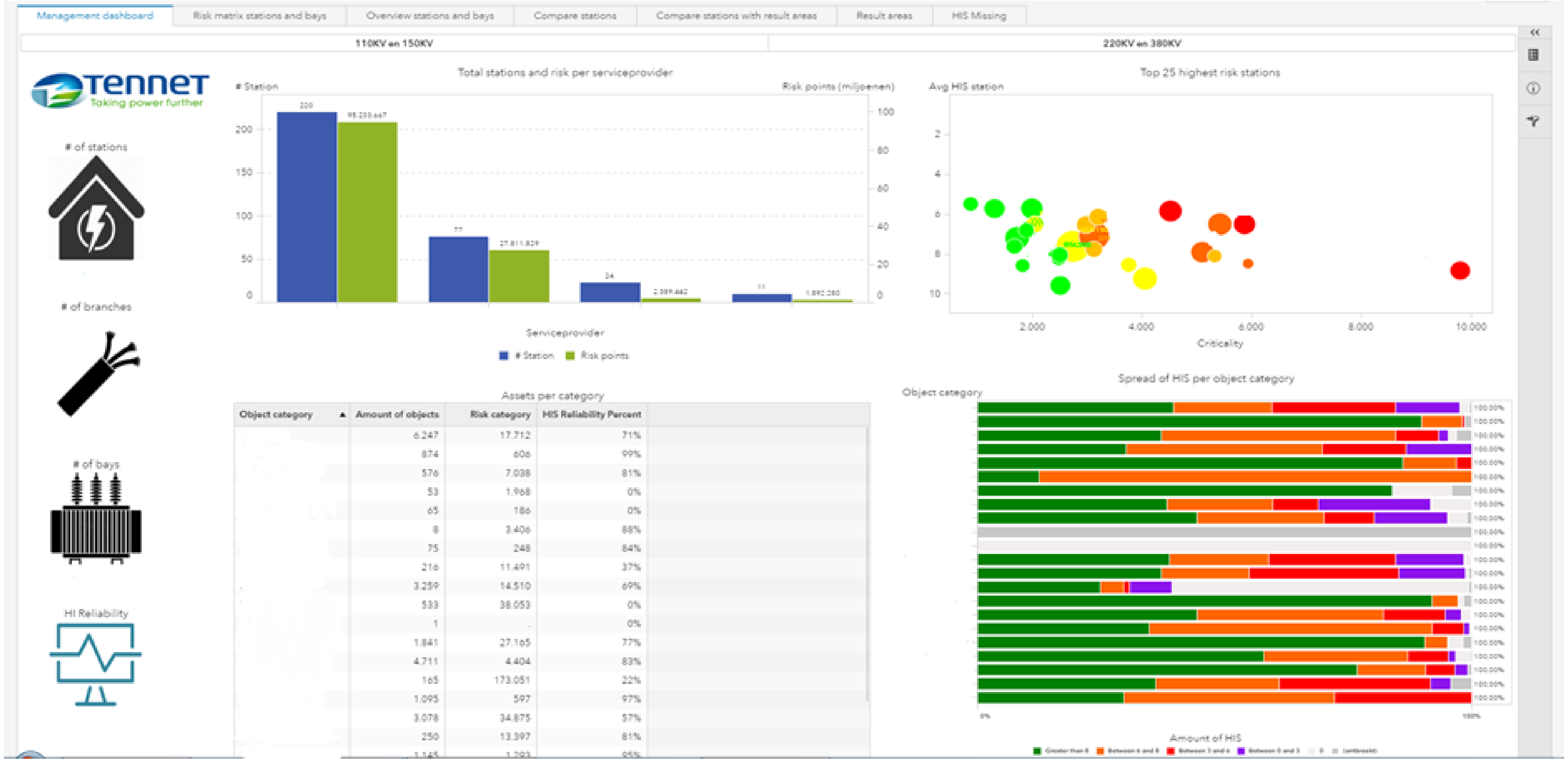
TENNET RISK MATRIX (ASSETS)			IMPACT 1 Minor	IMPACT 2 Small	IMPACT 3 Moderate	IMPACT 4 Considerable	IMPACT 5 Serious	IMPACT 6 Extreme
RESULT AREAS	Secure supply	Outage	See outage tables below	See outage tables below	See outage tables below	See outage tables below	See outage tables below	See outage tables below
RESULT AREAS	Secure supply	System Operations corrected overload	< 250 MVA	250 - 500 MVA	500 - 750 MVA	750 MVA - 1 GVA	1 - 1.5 GVA	> 1.5 GVA
RESULT AREAS	Engage stakeholders		Official complaint and/or internal unrest	Unrest in sector and/or minor media attention	Multiple official complaints	Regional political attention and/or negative position papers by NGO's	National media headline and/or national political attention	Long time national political attention
RESULT AREAS	Safety		Minor injury with first aid	Medical treatment by a general practitioner	Absence due to injury	Absence due to injury > 7 wk	Permanent injury	Casualty
RESULT AREAS	Financial		< 10K€	10 - 100 K€	100 K€ - 1 M€	1 - 10 M€	10 - 100 M€	> 100 M€
RESULT AREAS	Environment		Minor, possible to recover within limited time frame	Small, possible to recover	Moderate, difficult to recover	Considerable, very difficult to recover	Serious, hardly possible to recover	Extreme, not possible to recover
RESULT AREAS	Compliance		Complaints of violating rules	Formal request for information from authority or regulator	Formal warning or investigation	Fine or liability < 10 M€	Fine or liability > 10 M€ and/or instruction by regulator and/or criminal law procedure	Fine or liability > 100 M€ and/or criminal law sanction and/or rejection of license to operate
LIKELIHOOD	6 Almost certain	More than once a year	Low	Medium	High	Very High	Critical	Critical
LIKELIHOOD	5 Likely	Once every 1 - 10 years	Neglectable	Low	Medium	High	Very High	Critical
LIKELIHOOD	4 Probable	Once every 10 - 100 years	Neglectable	Neglectable	Low	Medium	High	Very High
LIKELIHOOD	3 Possible	Once every 100 - 1000 years	Neglectable	Neglectable	Neglectable	Low	Medium	High
LIKELIHOOD	2 Unlikely	Once every 1000 - 10,000 years	Neglectable	Neglectable	Neglectable	Neglectable	Low	Medium
LIKELIHOOD	1 Hardly possible	Less than once every 10,000 years	Neglectable	Neglectable	Neglectable	Neglectable	Neglectable	Low

*Failure Mode Effects and Criticality Analysis

Work flow
From data to model to dashboard



Result and dashboard



Next steps

- Health index does not give a predicting power for risk. So, we need to explore the possibility to adopt:
  - Predictive maintenance, OR,
  - HIT (Health Index TenneT) initiative, OR,
  - Market scenarios in IP (Investment Plan) cycle
- Harmonizing with the German risk model
- Lowering the number of assumptions in the current model

Content:
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Dashboard:
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Any questions, please contact me:

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Predictive Maintenance

SECURE SUPPLY TODAY AND TOMORROW

MAINTAIN THE GRID TO MEET RELIABILITY TARGETS

- Establish a clear and harmonized view on grid health and grid risk position
- **Scope and prioritize maintenance using data analytics and a risk-based approach to cut existing backlog and avoid one in future**
- Integrate work planning across departments by redefining accountability and workflow
- Ensure sufficient maintenance capacity by increasing resource effectiveness and the size of the qualified workforce

- Increased spending of resources on corrective maintenance reduces preventive maintenance resources
- Service provider capacity is limited, not all work orders can be executed
- Budget for repair transport services grows with 2.1 M€/yr

Bottom line:

- **Prioritize maintenance based on risk**
- **Become proactive in predicting failures**

Use case goal

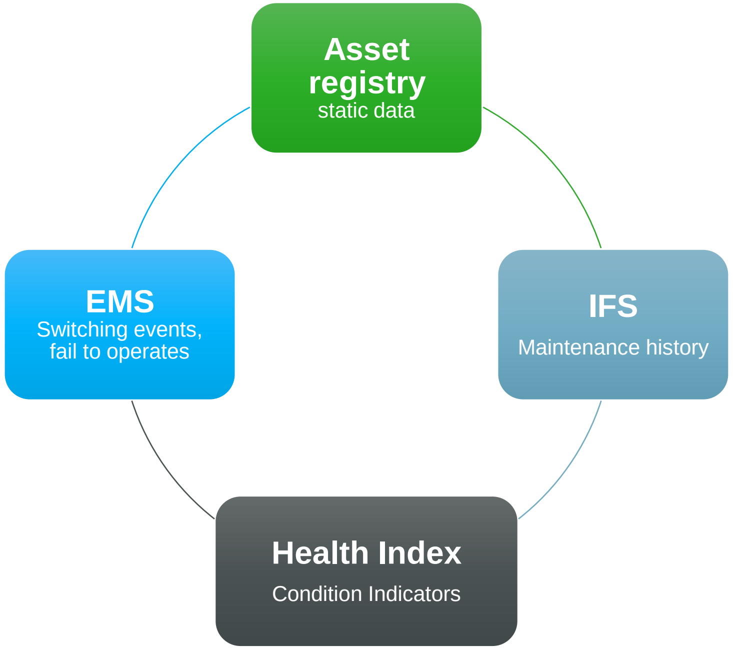
- **Question: Can we forecast the assets that will have failures in the next year?**

- Failure: corrective work order on asset

- Start ‘small’:
  - Disconnectors
  - Earthing switches
  - Circuit breakers

Dataset

- We combined several data sources
- Number of assets GS: 11,468 (75%)
- Data quality is poor
- Hard to link asset data together

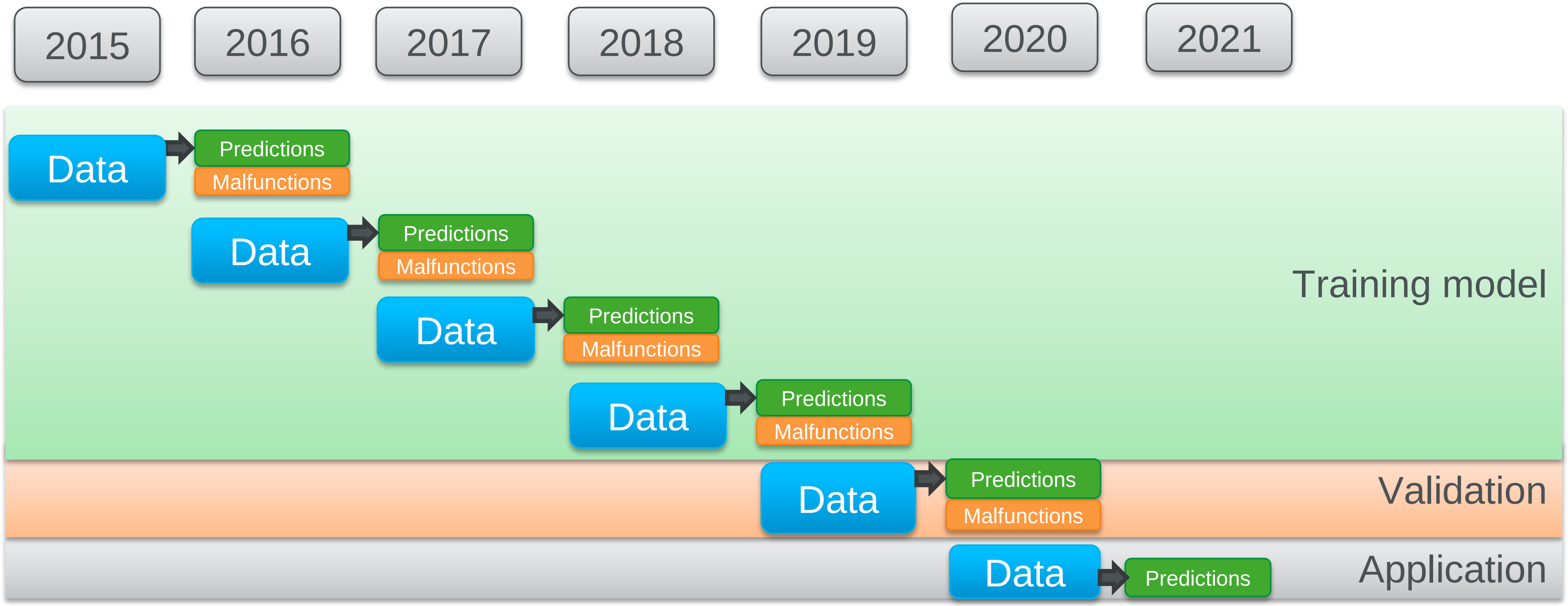


- Aggregate asset features per year (132 features):

	BMR_object-id	BMR_ouderobject-id	BMR_station-id	BMR_veld-id	BMR_veld-installatie_overdekt	BMR_veld-uitvoeringsvorm	BMR_uitvoeringsvorm	BMR_service_provider
4	AARDER.T283379	MDH150.02.ATT.150KV	MDH150	MDH150.02	nee	AIS	geen combi	Joulz BV
5	SCHEIDR.T311991	HTN150.35.SRA.150KV	HTN150	HTN150.35	nee	AIS	combi	TenneT GS
6	SCHEIDR.T311999	HTN150.35.SRB.150KV	HTN150	HTN150.35	nee	AIS	combi	TenneT GS
7	AARDER.T312201	HTN150.12.ALL.150KV	HTN150	HTN150.12	nee	AIS	combi	TenneT GS
8	AARDER.T312209	HTN150.12.ALS.150KV	HTN150	HTN150.12	nee	AIS	combi	TenneT GS

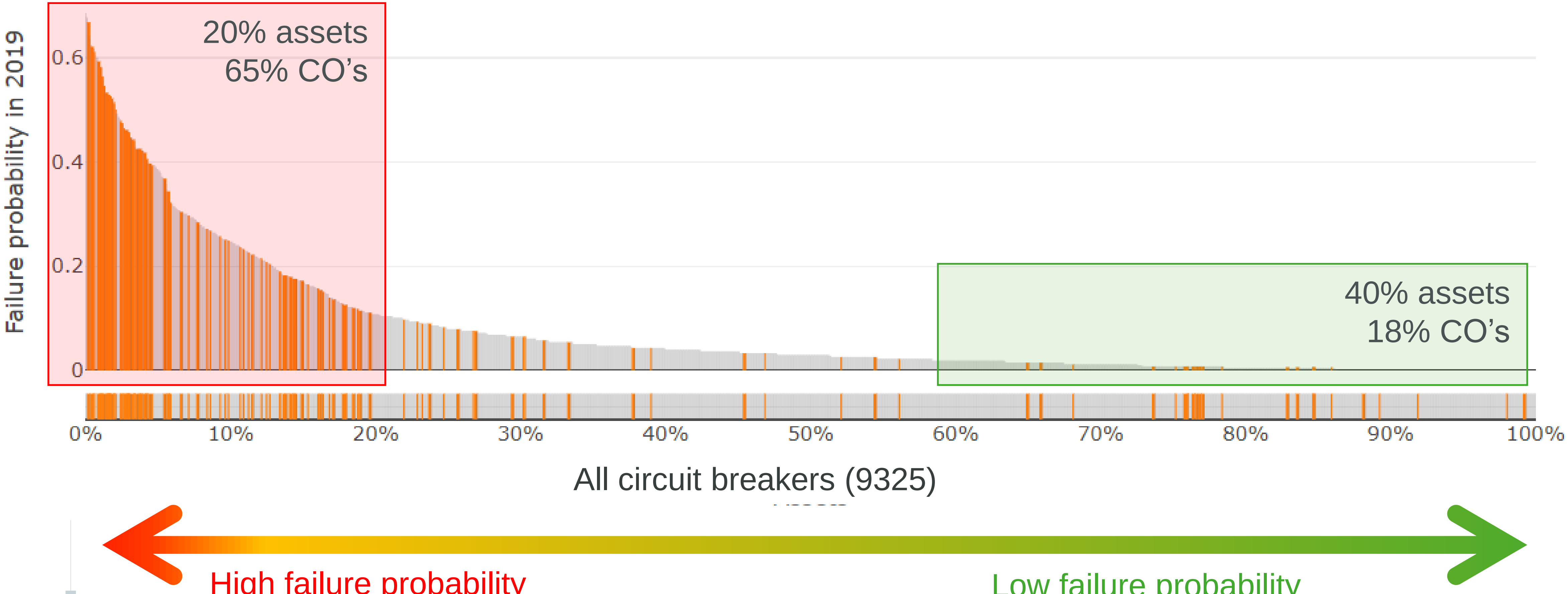
Data science model

- We train a machine learning model to classify the occurrence of failures on assets the next year
- Model is validated with failures of 2020

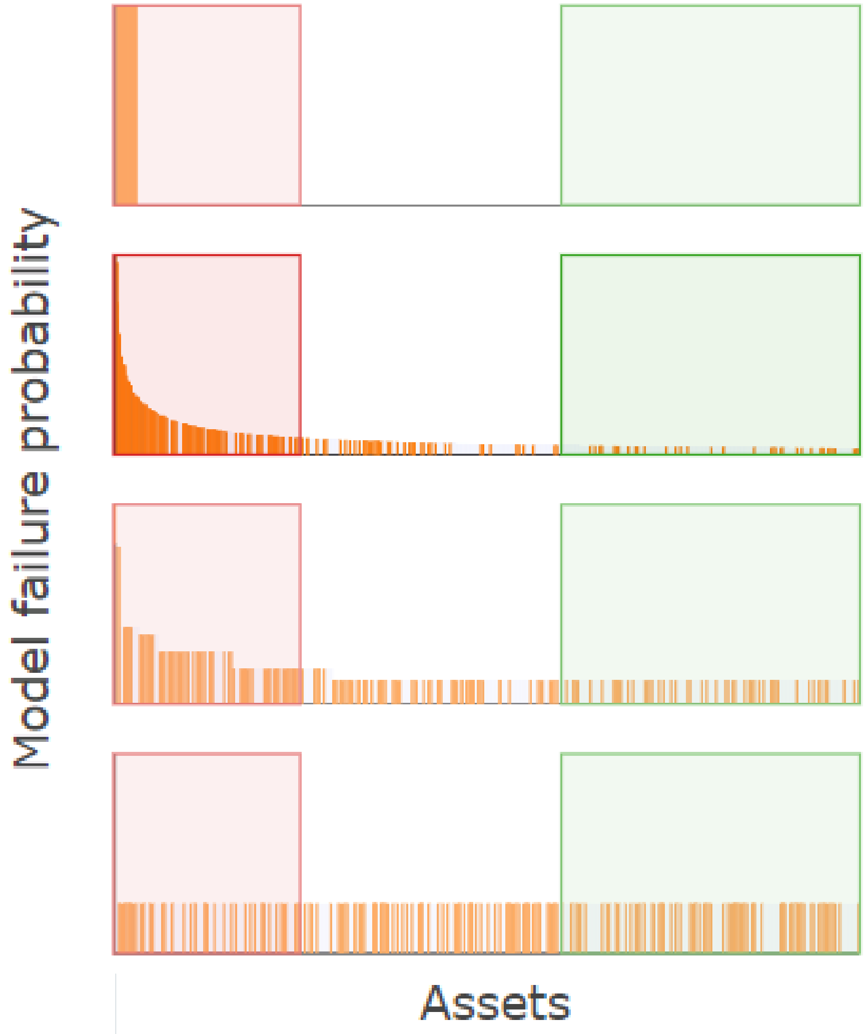


Asset failure probability

- Predict failures for 2021 based on failure data till 31-12-2020
- Validate with actual corrective work orders from 2020



Model comparison



Method: **Crystal ball**

25% most critical switches causes **100%** disruptions
40% best performing switches causes 0% disruptions

Method: **Data Science model**

25% most critical switches causes **70%** disruptions
40% best performing switches causes 18% disruptions

Method: **Health index**

25% most critical switches causes **31%** disruptions
40% best performing switches causes 29% disruptions

Method: **Random distribution**

25% most critical switches causes **25%** disruptions
40% best performing switches causes 40% disruptions

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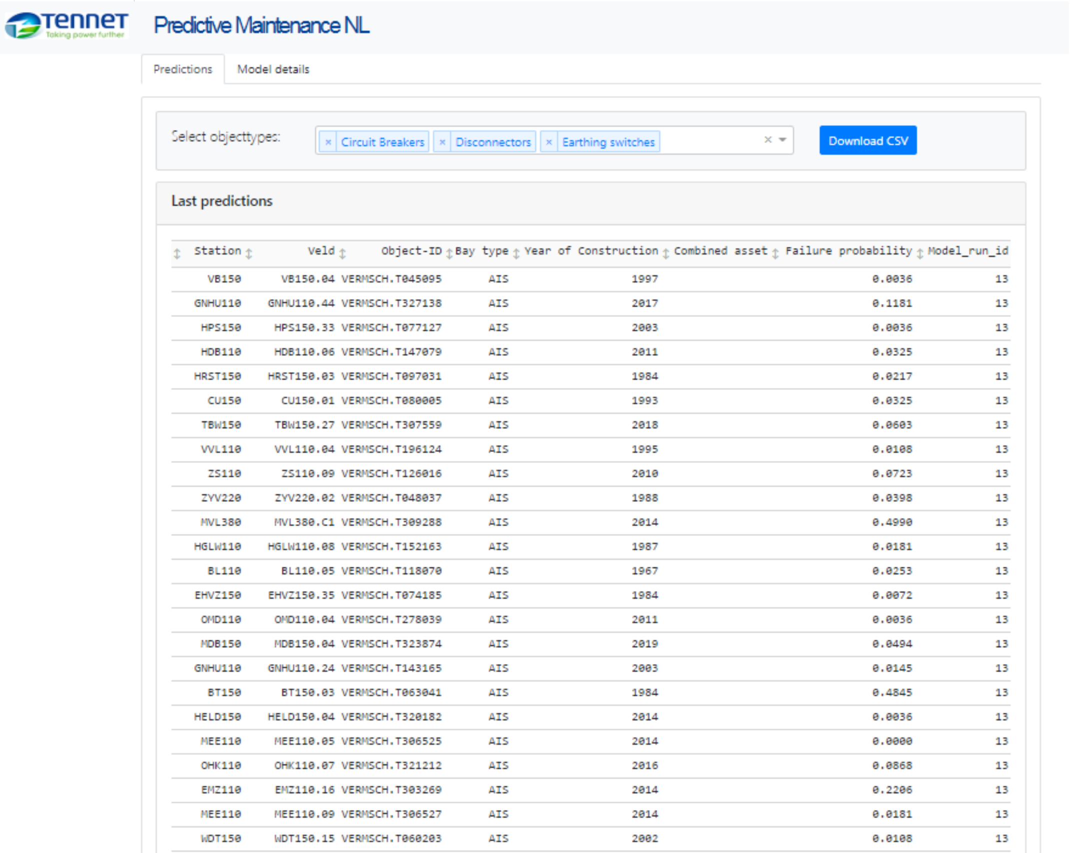
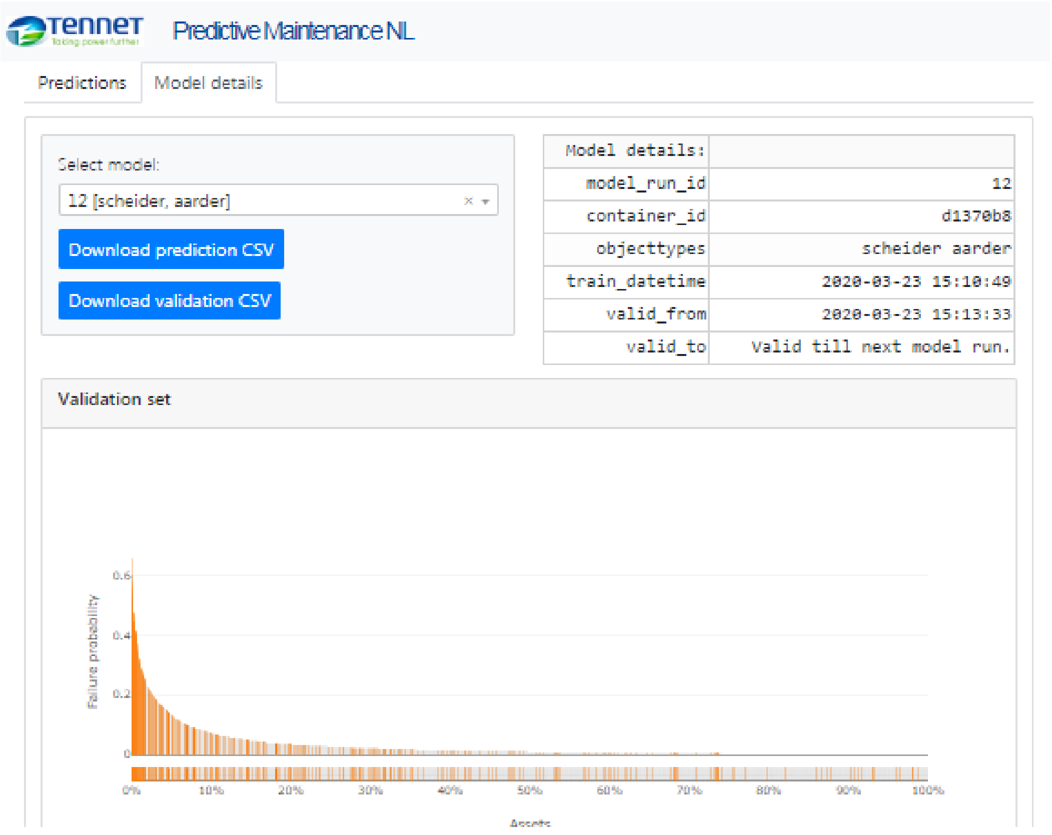
Dashboard

- Dashboard of the latest results is available on TenneT network:



Station	Veld	Object-ID	Bay type	Year of Construction	Combined asset	Failure probability	Model_run_id
VB150	VB150.04	VERMSCH.T045095	AIS	1997		0.0036	13
GNHU110	GNHU110.44	VERMSCH.T327138	AIS	2017		0.1181	13
HPS150	HPS150.33	VERMSCH.T077127	AIS	2003		0.0036	13
HDB110	HDB110.06	VERMSCH.T147079	AIS	2011		0.0325	13
HRST150	HRST150.03	VERMSCH.T097031	AIS	1984		0.0217	13
CU150	CU150.01	VERMSCH.T080005	AIS	1993		0.0325	13
TBW150	TBW150.27	VERMSCH.T307559	AIS	2018		0.0603	13
VVL110	VVL110.04	VERMSCH.T196124	AIS	1995		0.0108	13
ZS110	ZS110.09	VERMSCH.T126016	AIS	2010		0.0723	13
ZYV220	ZYV220.02	VERMSCH.T048037	AIS	1988		0.0398	13
MVL380	MVL380.C1	VERMSCH.T309288	AIS	2014		0.4990	13
HGLW110	HGLW110.08	VERMSCH.T152163	AIS	1987		0.0181	13
BL110	BL110.05	VERMSCH.T118070	AIS	1967		0.0253	13
EHVZ150	EHVZ150.35	VERMSCH.T074185	AIS	1984		0.0072	13
OMD110	OMD110.04	VERMSCH.T278039	AIS	2011		0.0036	13
MDB150	MDB150.04	VERMSCH.T323874	AIS	2019		0.0494	13
GNHU110	GNHU110.24	VERMSCH.T143165	AIS	2003		0.0145	13
BT150	BT150.03	VERMSCH.T063041	AIS	1984		0.4845	13
HELD150	HELD150.04	VERMSCH.T320182	AIS	2014		0.0036	13
MEE110	MEE110.05	VERMSCH.T306525	AIS	2014		0.0000	13
OHK110	OHK110.07	VERMSCH.T321212	AIS	2016		0.0868	13
EMZ110	EMZ110.16	VERMSCH.T303269	AIS	2014		0.2206	13
MEE110	MEE110.09	VERMSCH.T306527	AIS	2014		0.0181	13
WDT150	WDT150.15	VERMSCH.T060203	AIS	2002		0.0108	13



Model details:	
model_run_id	12
container_id	d1370b8
objecttypes	scheider aarder
train_datetime	2020-03-23 15:10:49
valid_from	2020-03-23 15:13:33
valid_to	Valid till next model run.

Lessons learned

- Amount of data points
- Asset amount
- Data availability

Further plans

- Extension plans:
  - Include additional object types like: Power transformers

  - Include ESP ERP data:
    - Reddyn PoC complete
    - Creation of data pipe under analysis
    - Incl. “ONB” on planned outage

  - Implement to Health indexing

  - Extract live data

Questions

- Question to you all:
  - Do you have something simulate in your company?
  - How would you use it in your day to day work?

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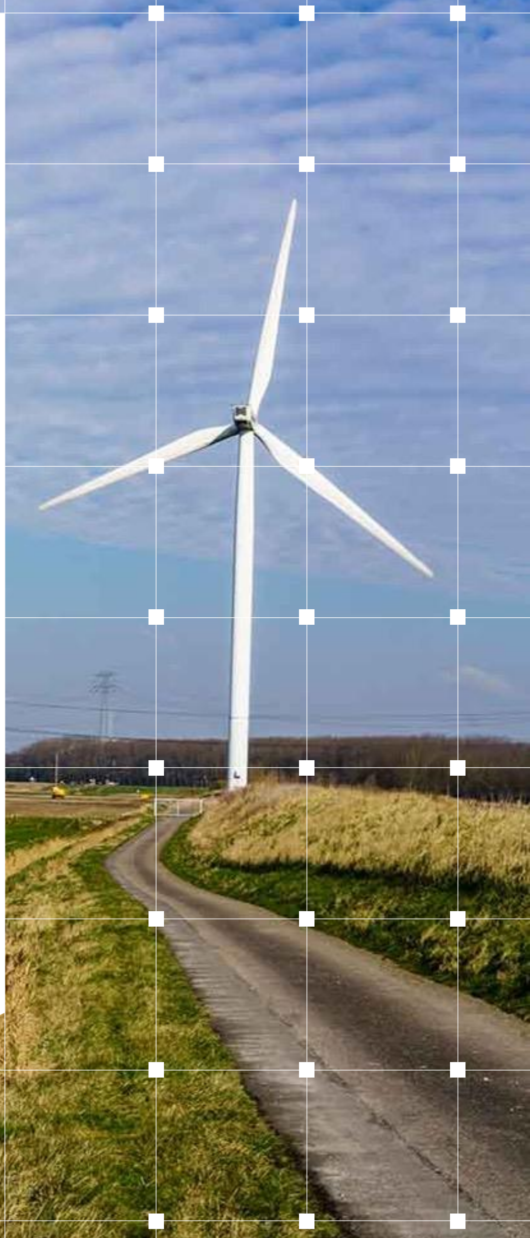
Lighting the way ahead together.



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