Decision-making process for substation renovation and equipment end of life assessment

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Decision-making process for substation renovation and equipment end of life assessment

1. Introduction (German EHV grid)
2. Basic methodology
3. Ascertainment of actual condition
4. Determination of other c - parameters
5. Assessment of end of service life
6. Combination of parameters for decision making
7. Conclusion

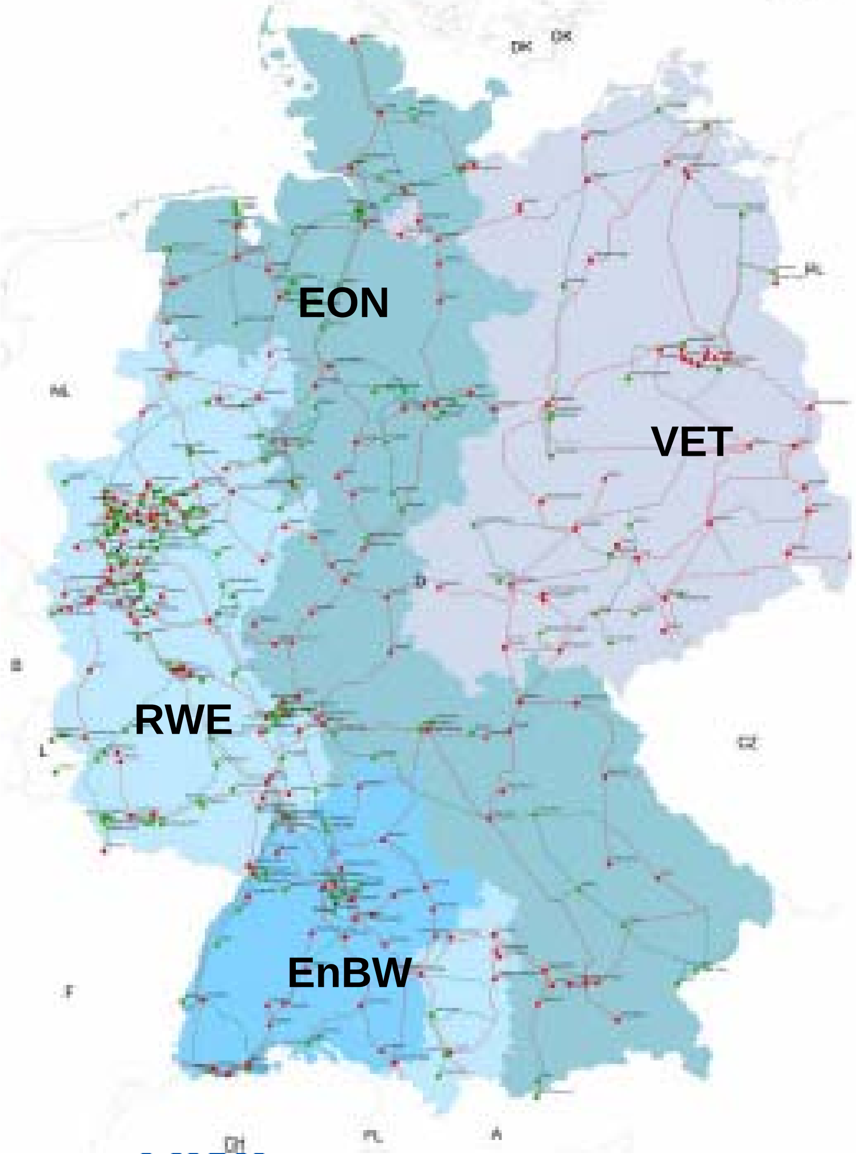
Introduction

- Fundamental changes in the regulatory framework of the electricity market in the last decade
- Intensified efforts of the grid operators for an optimized utilization of their networks with respect to technical and economical aspects
- At the same time the grid operators have to assure a sufficient power quality & reliability
- Substations are the nodes of the grid substantially affecting the reliability & availability of the grid in total
- Substations represent an essential part of the grid assets
- Of particular interest with regard to optimization of the grid costs, i. e. investments & operational expenditure – CAPEX & OPEX

⇒ Methodology and decision making process for substation renovation and equipment end of life assessment

German EHV grid

Operational areas of German Transmission System Operators



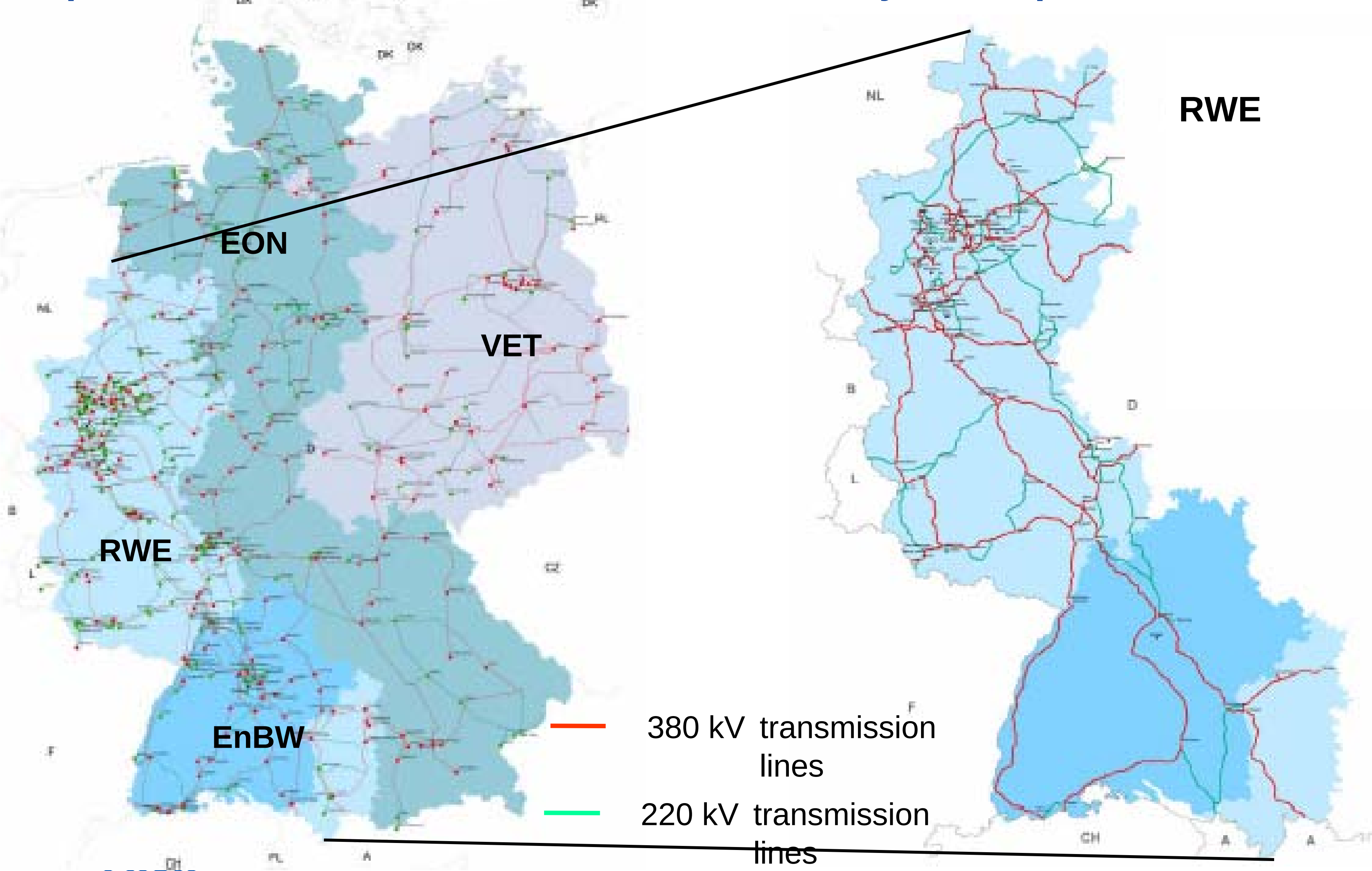
	RWE	E.ON	VET	EnBW
Network length 380 kV [km]	5,200	5,400	6,700	1,936
Network length 220 kV [km]	6,100	5,300	2,865	1,721
Served area [1000 km²]*	73.1	139.4	109.0	34.6
Annual transmission [TWh]	175	138	k.A.	76
Share load [%]**	38	30	19	13

* in Germany

** Renewable Energy Act load compensation 2005

German EHV grid

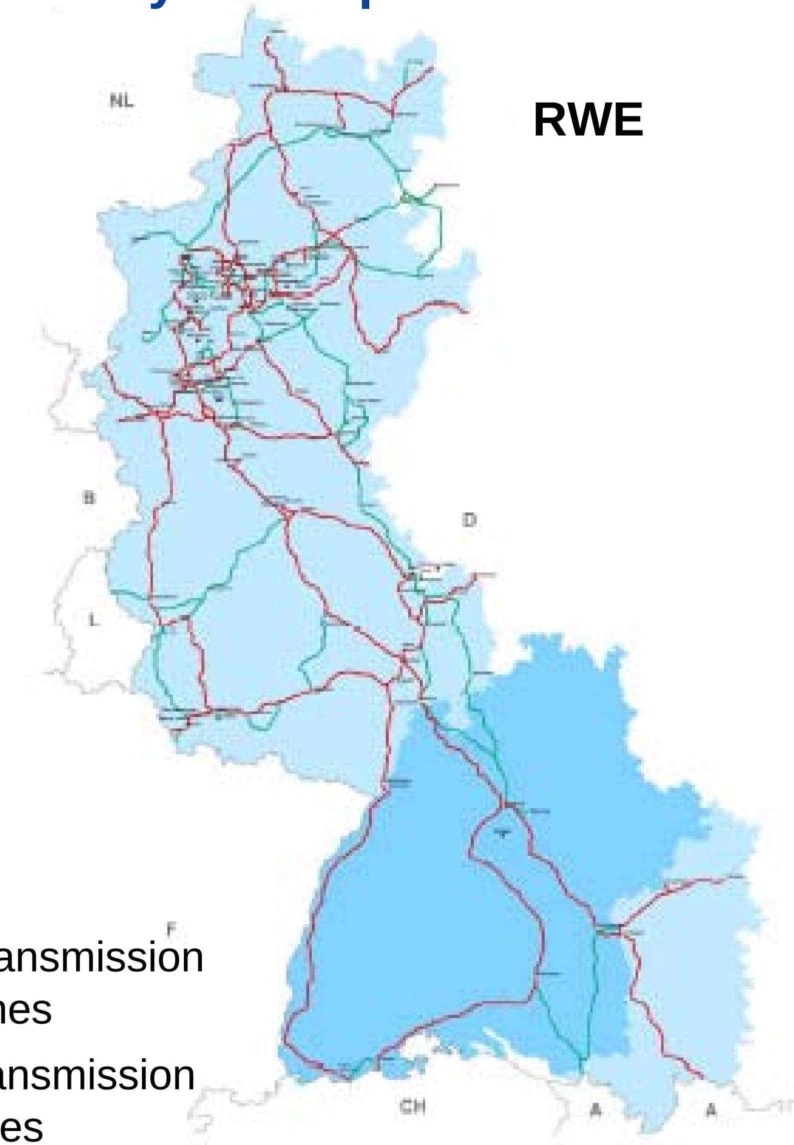
Operational areas of German Transmission System Operators



German EHV grid

Operational areas of German Transmission System Operators

380 kV circuits	5,200 km	
220 kV circuits	6,100 km	
380 kV substations	62	
220 kV substations	110	
110 kV substations	121	
380 kV transformer	235	90,100 MVA
220 kV transformer	145	



380 kV transmission lines

220 kV transmission lines

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Information for decision making process

- AM ⇔ qualified information of the system and the equipment installed for the decision making process.

- In case of larger population difficult to provide key information manually; therefore reasonable
  - application of data based systems
  - development of algorithms

- Algorithms and method for
  - determining near-term action and annual business planning
  - forecasting the technical and financial effect due to system ageing

- Approach based on condition and importance

Assessment of condition and importance parameters (1)

■ Assessment of condition parameters

1. Equipment level regarding equipment specific condition parameters, assessment by school marks

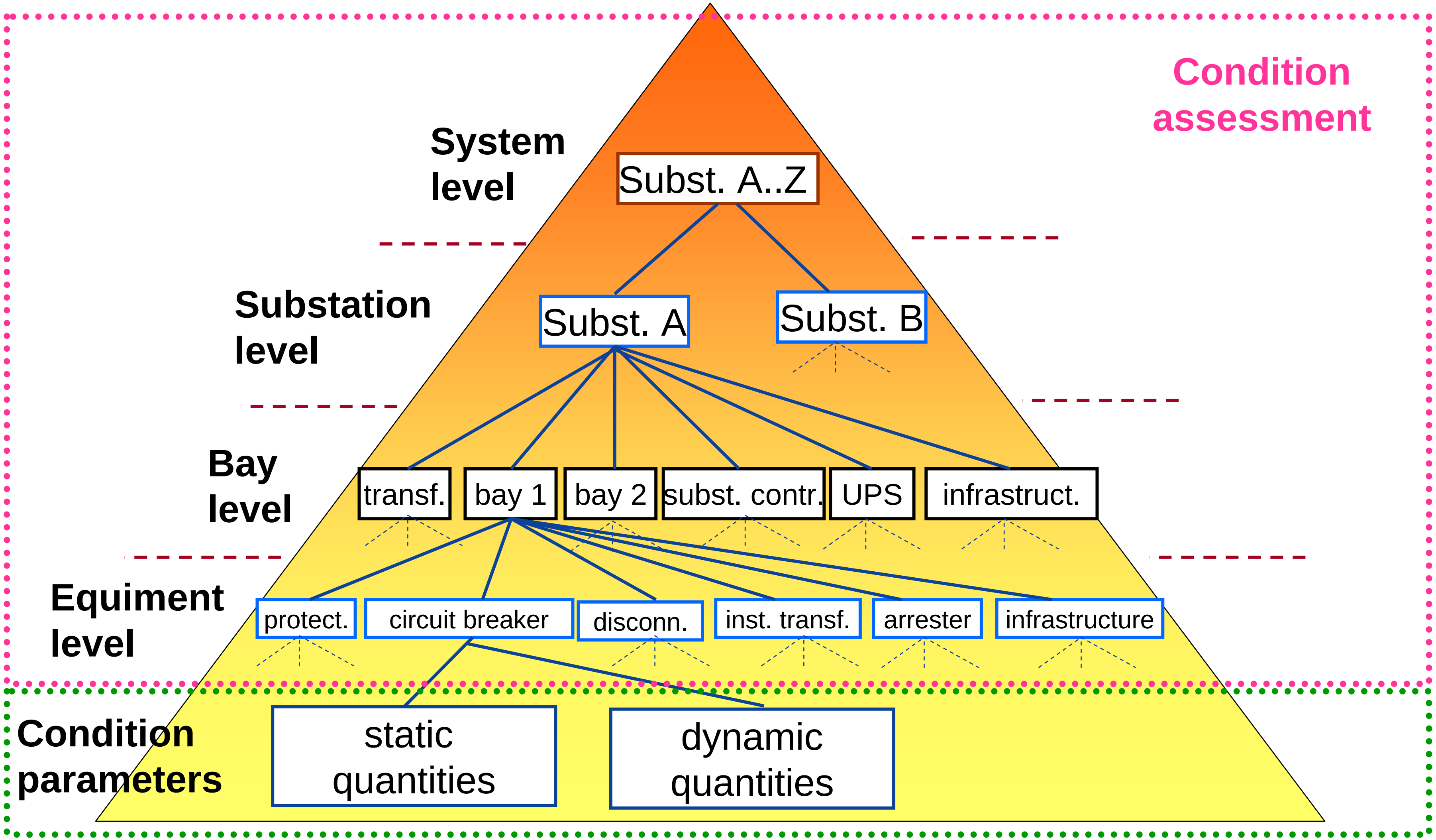
   - **static condition quantities:** technology, type related service experience (e. g. after sales service quality, maintenance costs), individual failure rates

   - **dynamic condition quantities:** age of equipment, individual condition ascertained by inspection and condition checks, interval to next planned maintenance activity

2. Equipment condition parameters accumulated on bay level, weighted according the value of different equipment

3. Assessment on station level → bay condition parameters and on system level → station condition parameters, weighted average mean value

Assessment of condition parameters on different levels



Assessment of condition and importance parameters (2)

- Assessment of importance parameters
  - ~~Reliability analysis of the different substations~~
  - Derived from short circuit power of the station in question

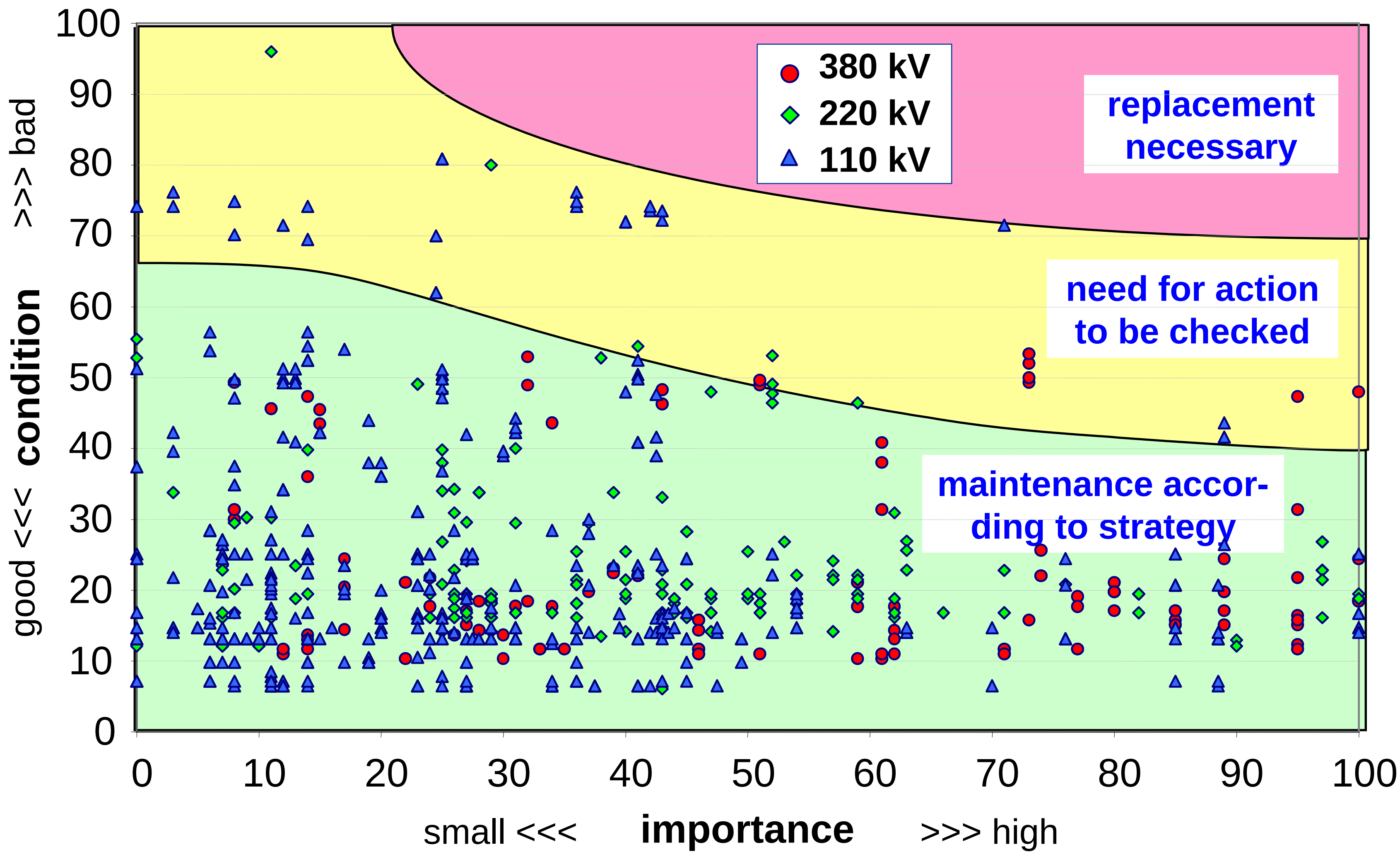
    weighted by a factor reflecting the relevance of the station in the system

For reliability analysis failure rates to be regarded. However, failure rates still considered with

- Condition and importance parameters normalised to 100

Condition and importance on equipment level

Example: Circuit breakers



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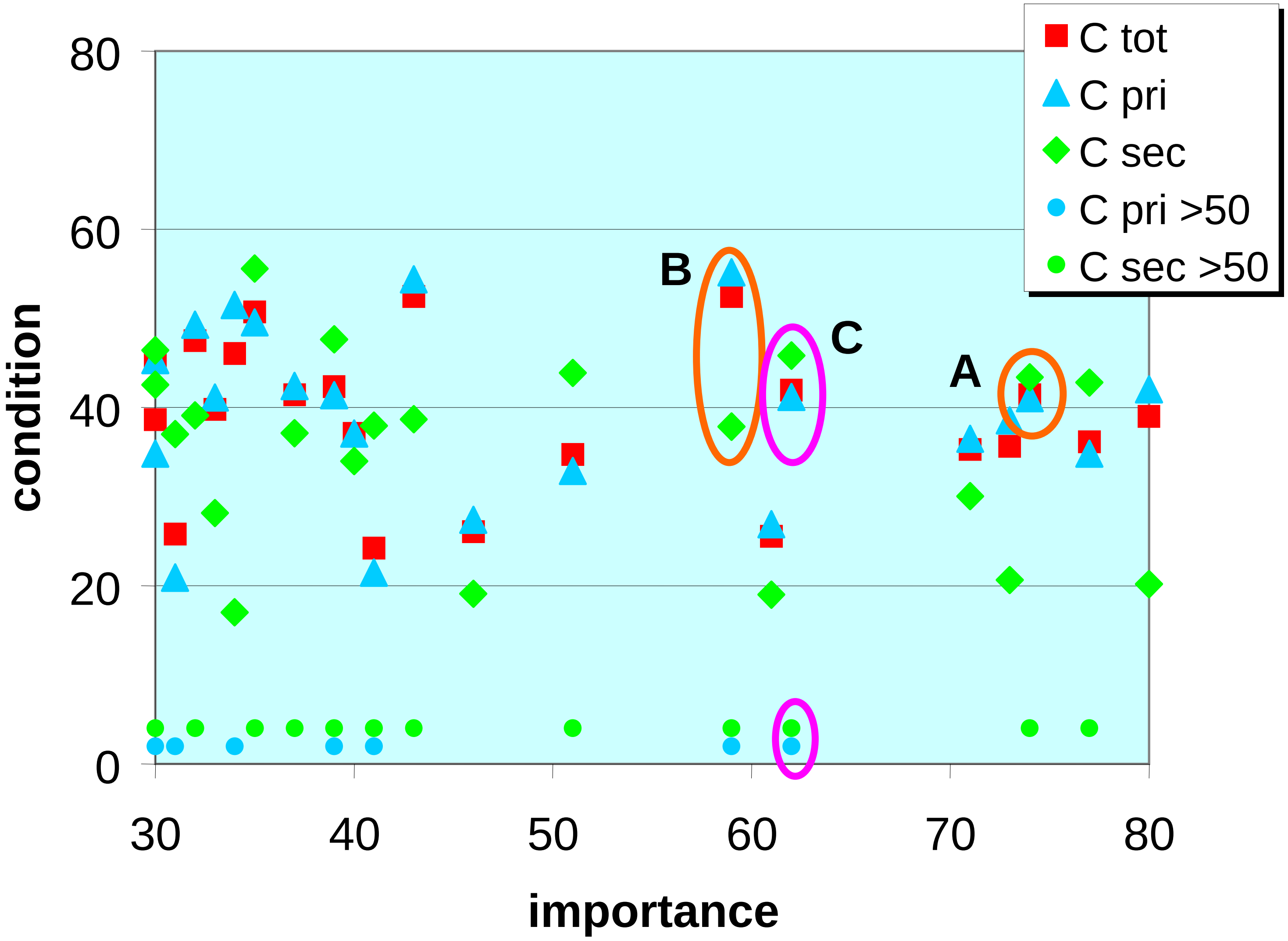
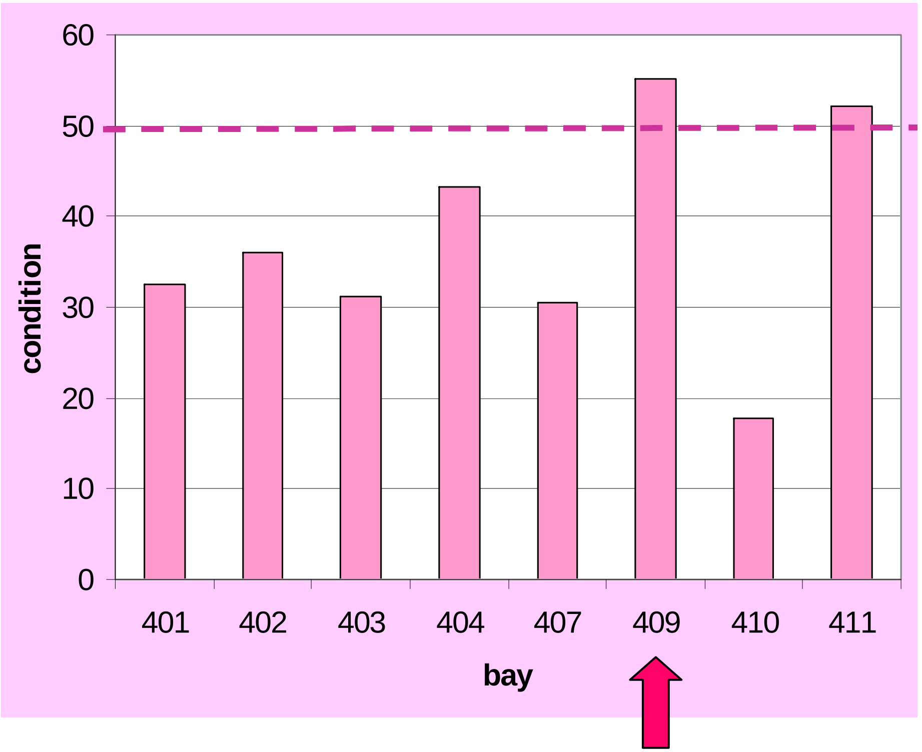
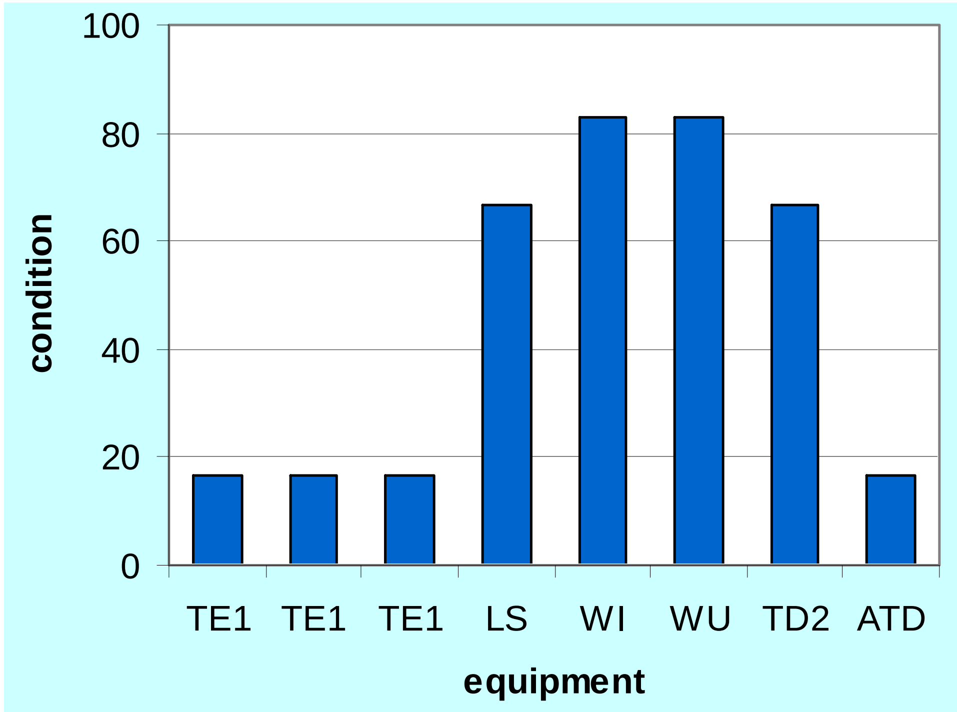
Condition and importance parameters of a population of 380 kV stations



Condition on station level and bay level
– condition above 50 –





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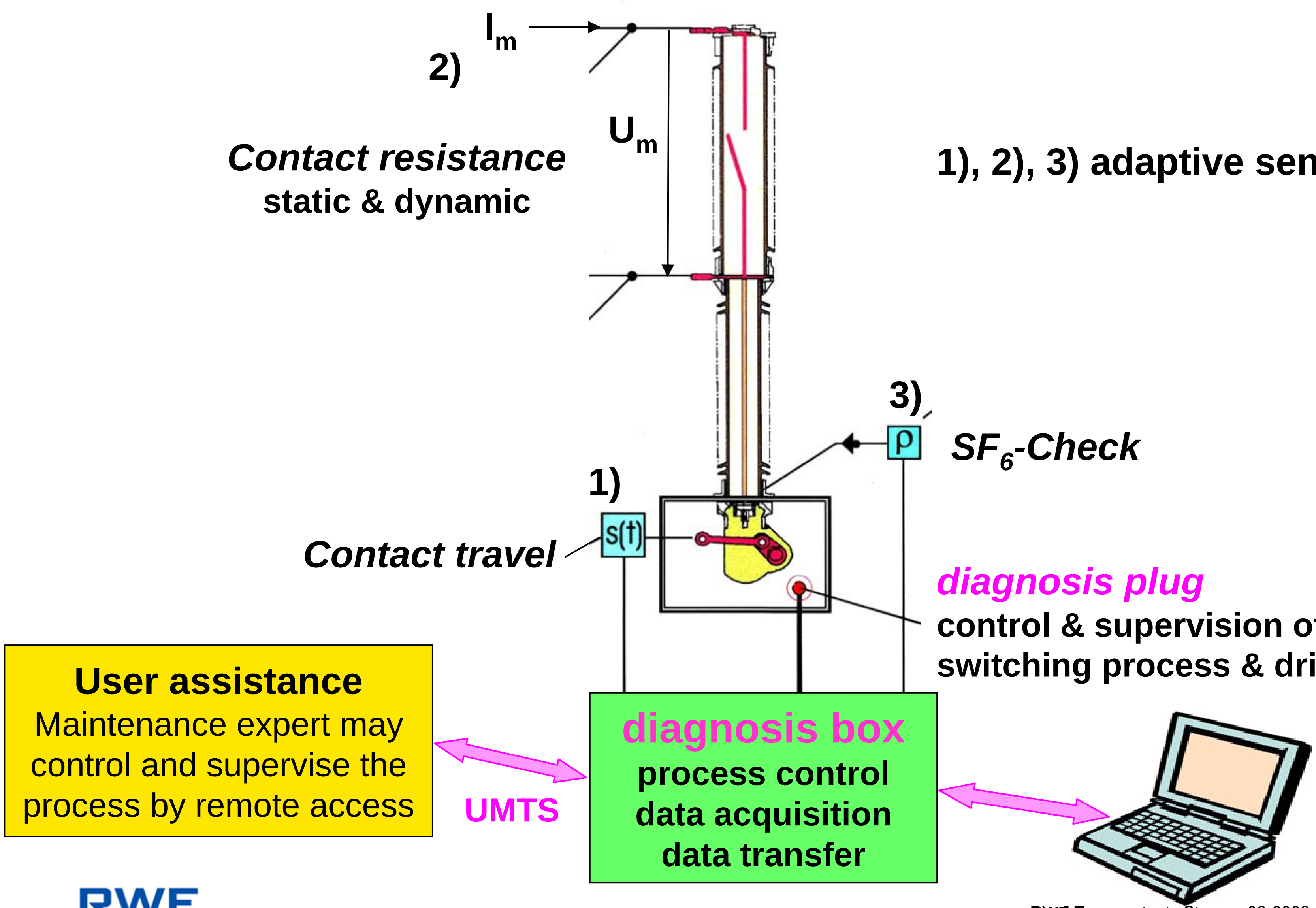
Qualified assessment of actual condition of switching equipment

- Qualified condition assessment needs knowledge of the equipment under consideration and the physical background $\Rightarrow$ experienced and highly skilled personnel.
- In case of a large amount of different pieces of equipment and of different types $\Rightarrow$ high expenditure for training of specialised personnel
- $\Rightarrow$ New approach: Application of an “automated, user instructed and data based inspection and diagnosis system” (ADS)
- ADS system in use for HV CBs since several years, for DSs under development

Basic design of “ADS“ system

(automated, user instructed and data based inspection and diagnosis)



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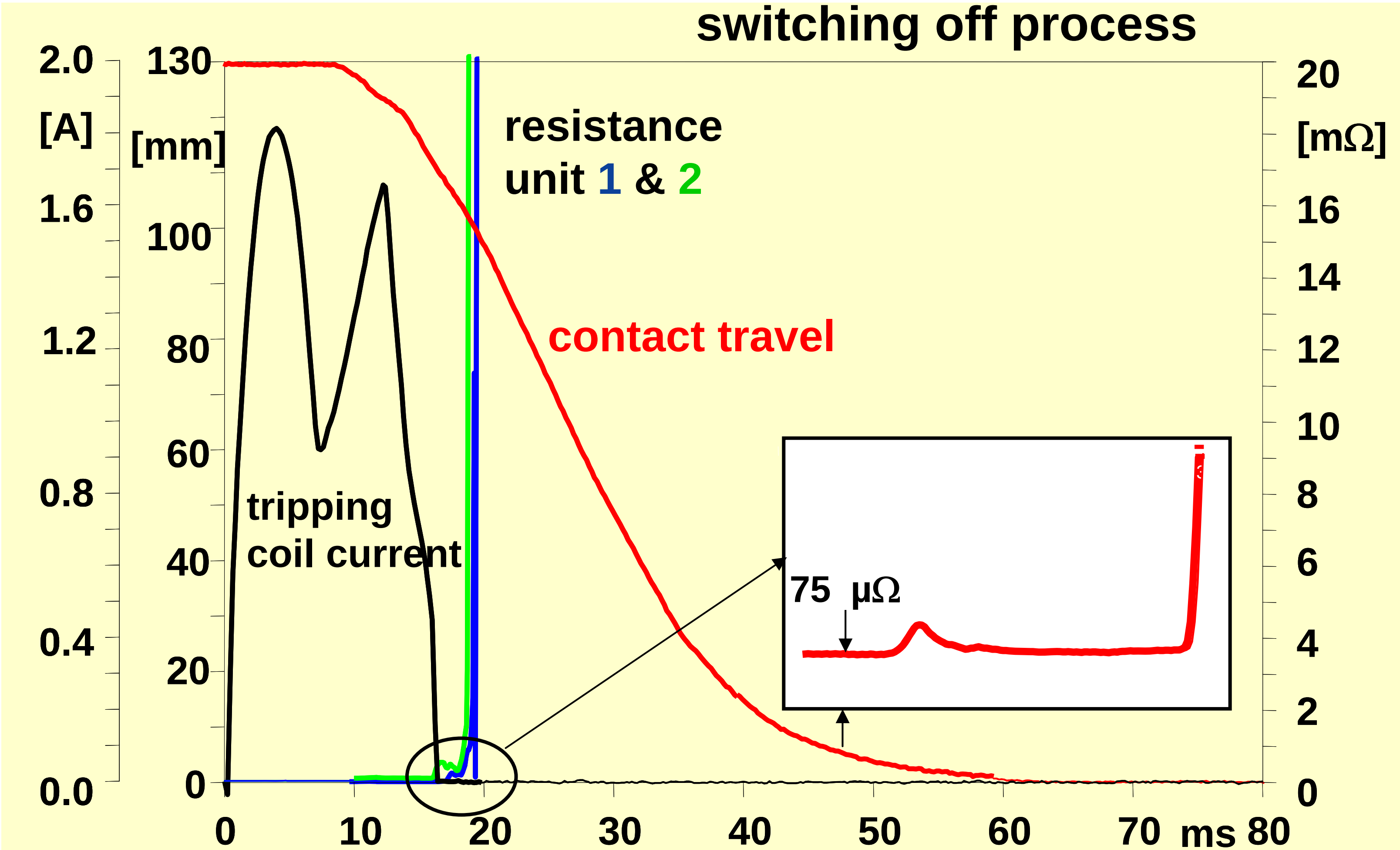
ADS Features

- Diagnostic box → four inputs to record different diagnostic quantities
- Sequence of the inspection process is automated:
- After input of the general data of the breaker to be inspected → maintenance personnel instructed what actions are to be done
- All quantities are measured & analysed automatically, all results are stored in a data base
- ⇒ Reliable, objective & qualified assessment of the actual condition of the equipment under consideration
- Depending on the measuring results and the condition check → information, if and what corrective measures have to be taken.

Results of ADS diagnosis on a 245 kV CB with two interrupter units



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Data recorded and analysed by a single shot

- The following data can be recorded and analysed by a single shot:
- Static and dynamic contact resistance
- Operating (making or breaking) time of the main and the auxiliary contacts
- Contact travel, i. e. velocity and damping
- Current and time characteristic of the tripping coil
- In case of an hydraulic drive pressure drop of the hydraulic pressure
- All measured results are recorded and analyzed automatically and afterwards stored in a data base.

Decision-making process for substation renovation and equipment end of life assessment

1. Introduction
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4. Determination of other c – parameters
   - Maintenance,
   - after sales service
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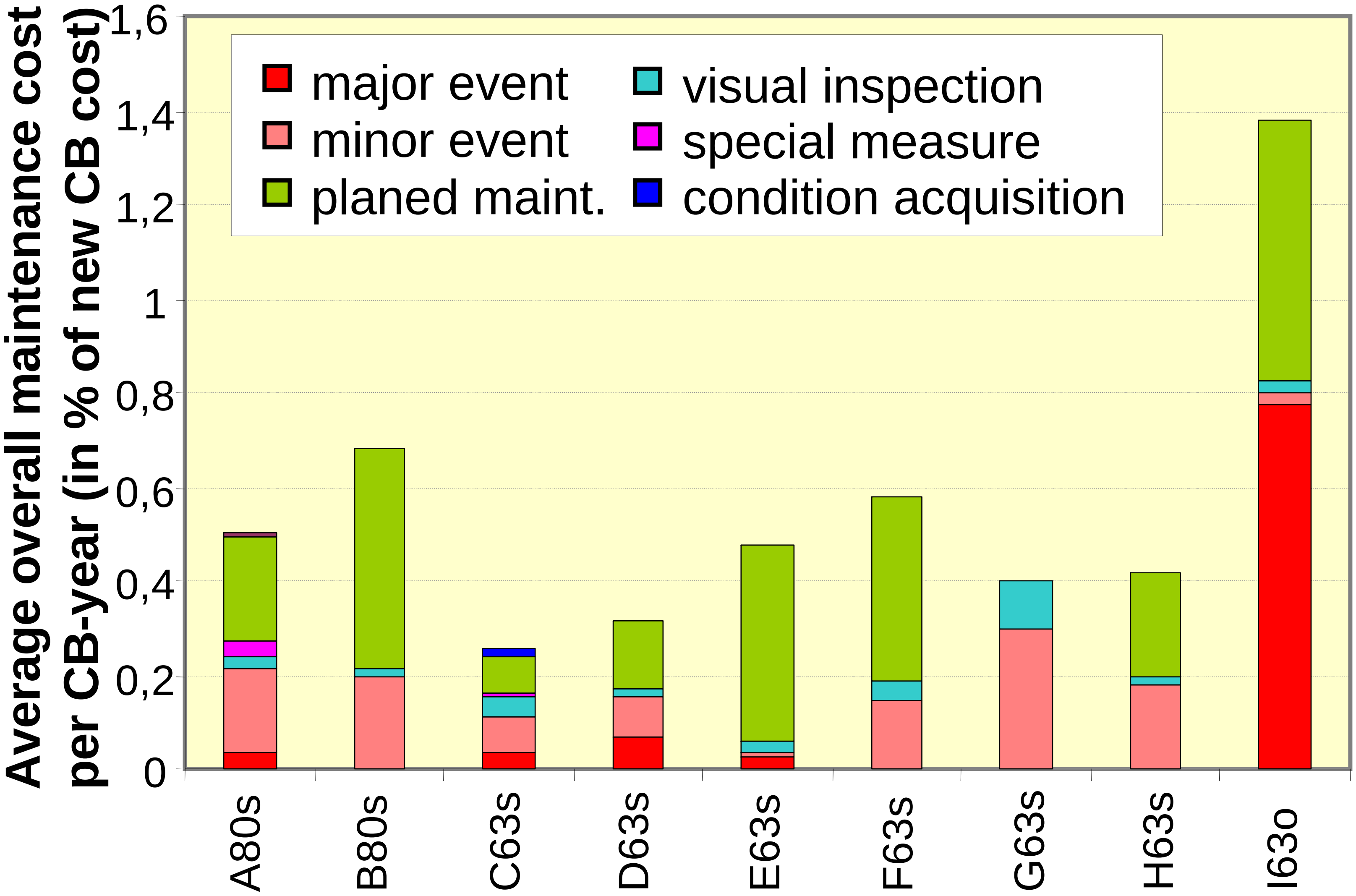
Average overall maintenance costs of 420 kV CBs per CB-year



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Assessment of after sales service quality (CBs)

	...wer for ...ation	In... ...on time	fe... ...y of CB ...se	F... ...ck with ...acturer	Stuff availability for failure removal	Assembly time in case of failure	Availability of spare parts	Stuff availability for maintenance	Quality of maintenance	Cost of maintenance package	Time of unavailability during maintenance	**Assessment results**
Weight [%]	1.8	8.0	8.0	15.6	8.0	11.6	13.5	5.5	9.8	15.9	3.3	100
Range	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	0-100
Type A80s	3	5	1	2	1	3	1	1	1	3	[illegible]	**21.6**
Type B80s	5	5	6	5	5	5	5	[illegible]	[illegible]	[illegible]	[illegible]	**78.6**
Type C63s	2	2	1	2	1	2	1	[illegible]	[illegible]	[illegible]	[illegible]	**10.8**
Type D63s	5	5	6	2	1	3	1	1	1	3	3	**30.6**
Type E63s	3	5	1	3	3	2	2	3	3	2	2	**31.7**
Type F63s	3	5	1	5	5	2	2	3	5	1	1	**42.5**
Type G63s	5	5	1	5	5	2	2	3	5	1	1	**43.2**
Type H63s	3	5	1	5	5	3	3	3	5	3	4	**53.8**
Type I63o	5	5	6	5	5	5	3	3	5	6	6	**76.9**

Weighting by a decision matrix

Best service 0
Worst service 100

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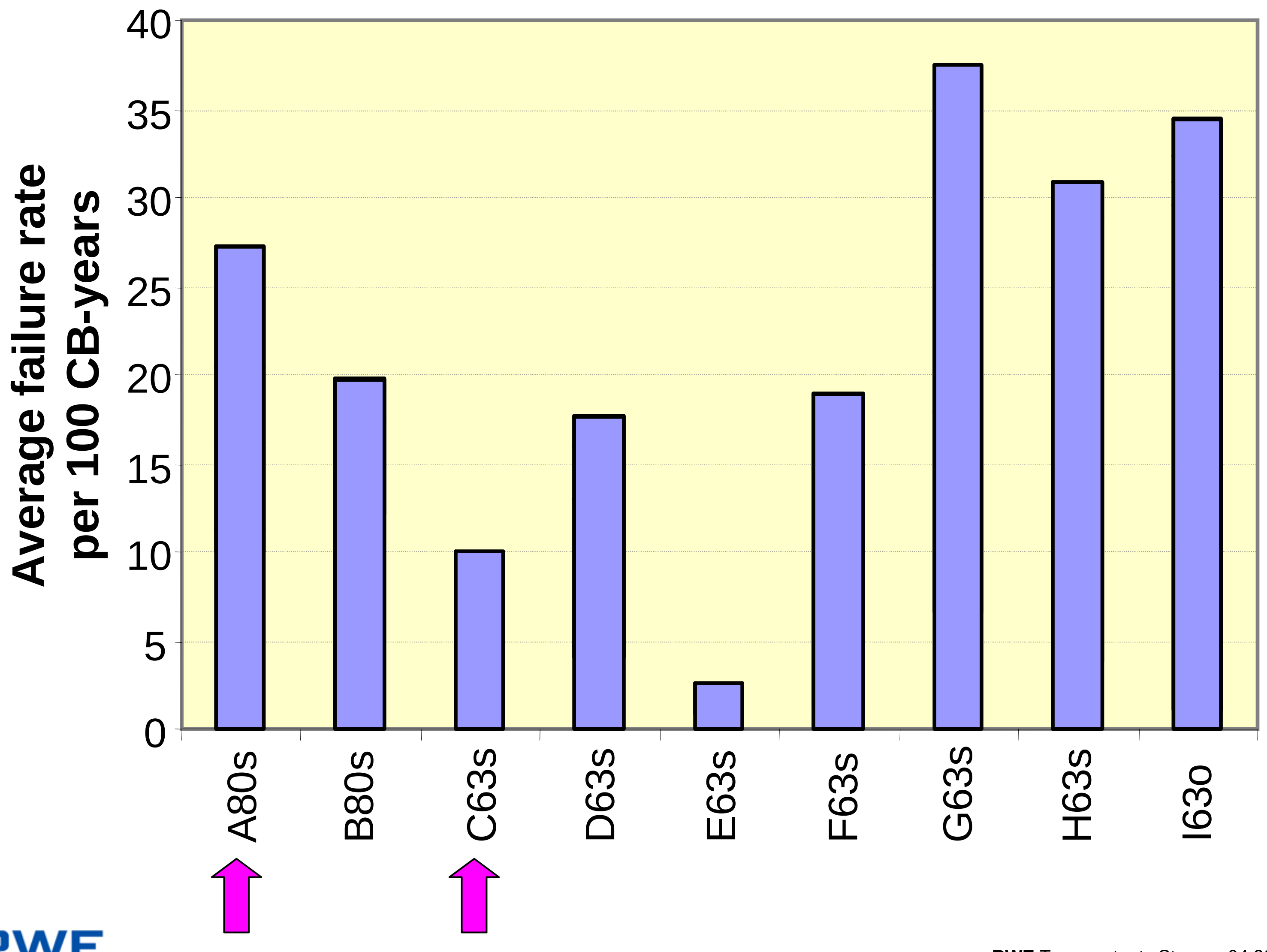
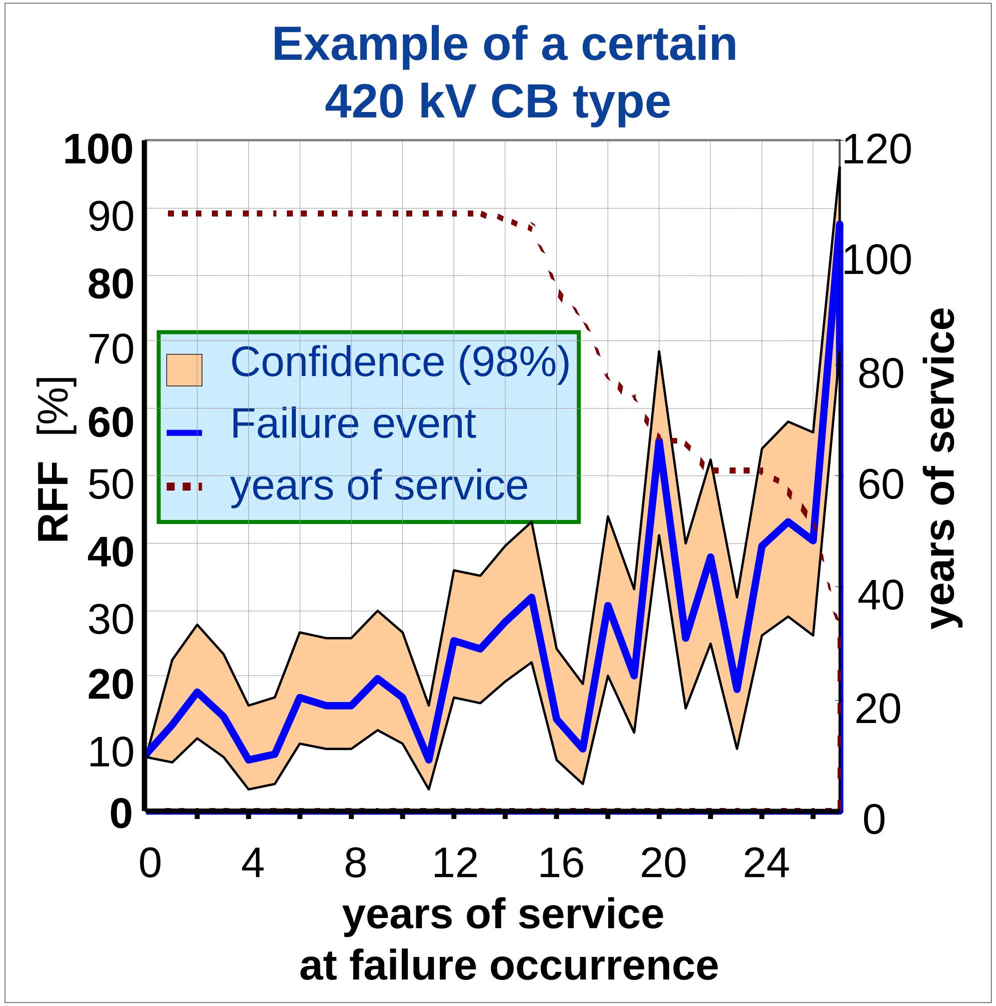
Average failure rates of 420 kV CBs



Ageing given by related failure frequency (RFF)

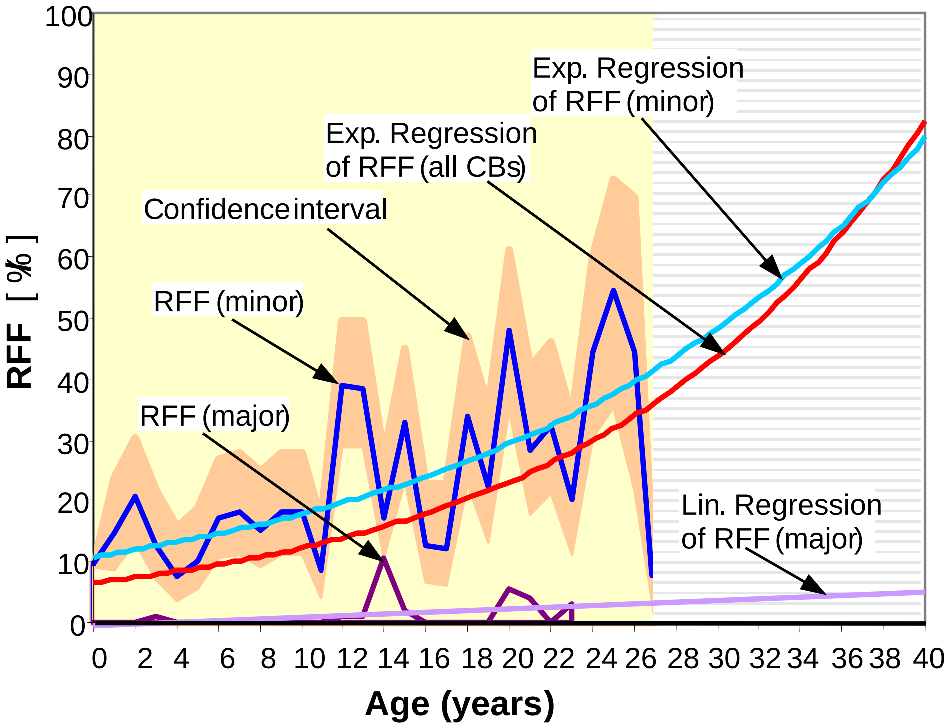


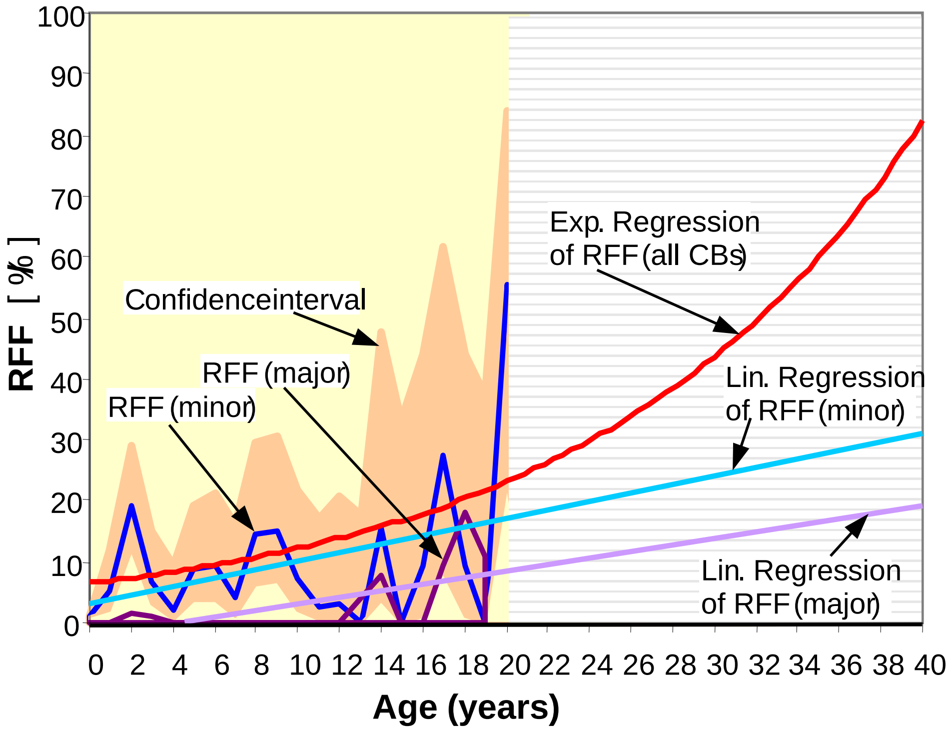
- Typical ageing process
  - Linear loss of basic substance
  - Exponentially increasing related failure frequency
  - Worse service experience for older equipment

RFF: Failures per year related to 100 CB years [%]

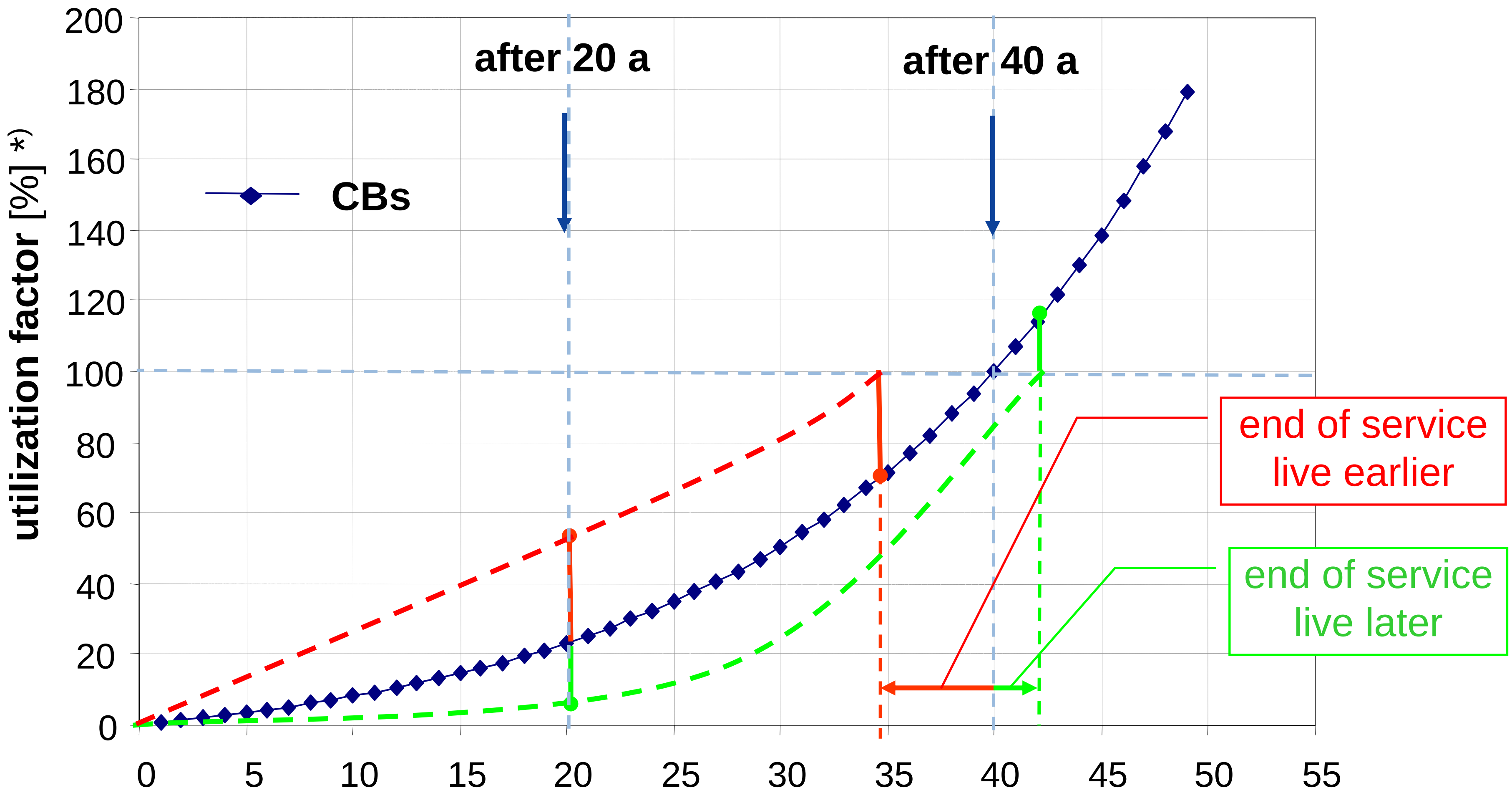
Related failure Frequency (RFF) of 420 kV CBs

Failure Frequency (RFF) of 420 kV circuit breakers with 95% confidence interval



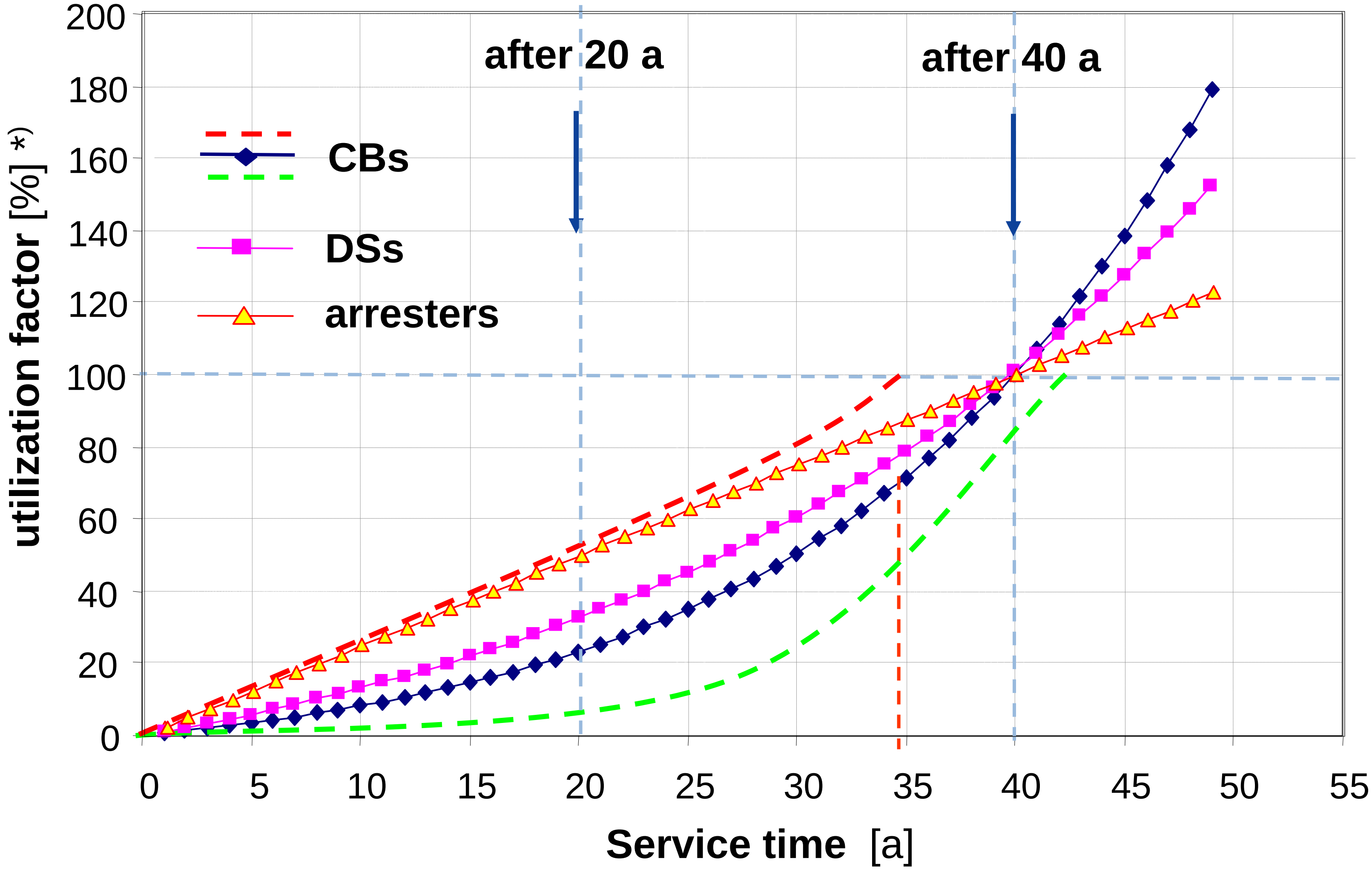


End of life prognosis due to knowledge of the basic ageing process



⇒ In case of accelerated ageing renovation is brought forward, in case of decelerated postponed

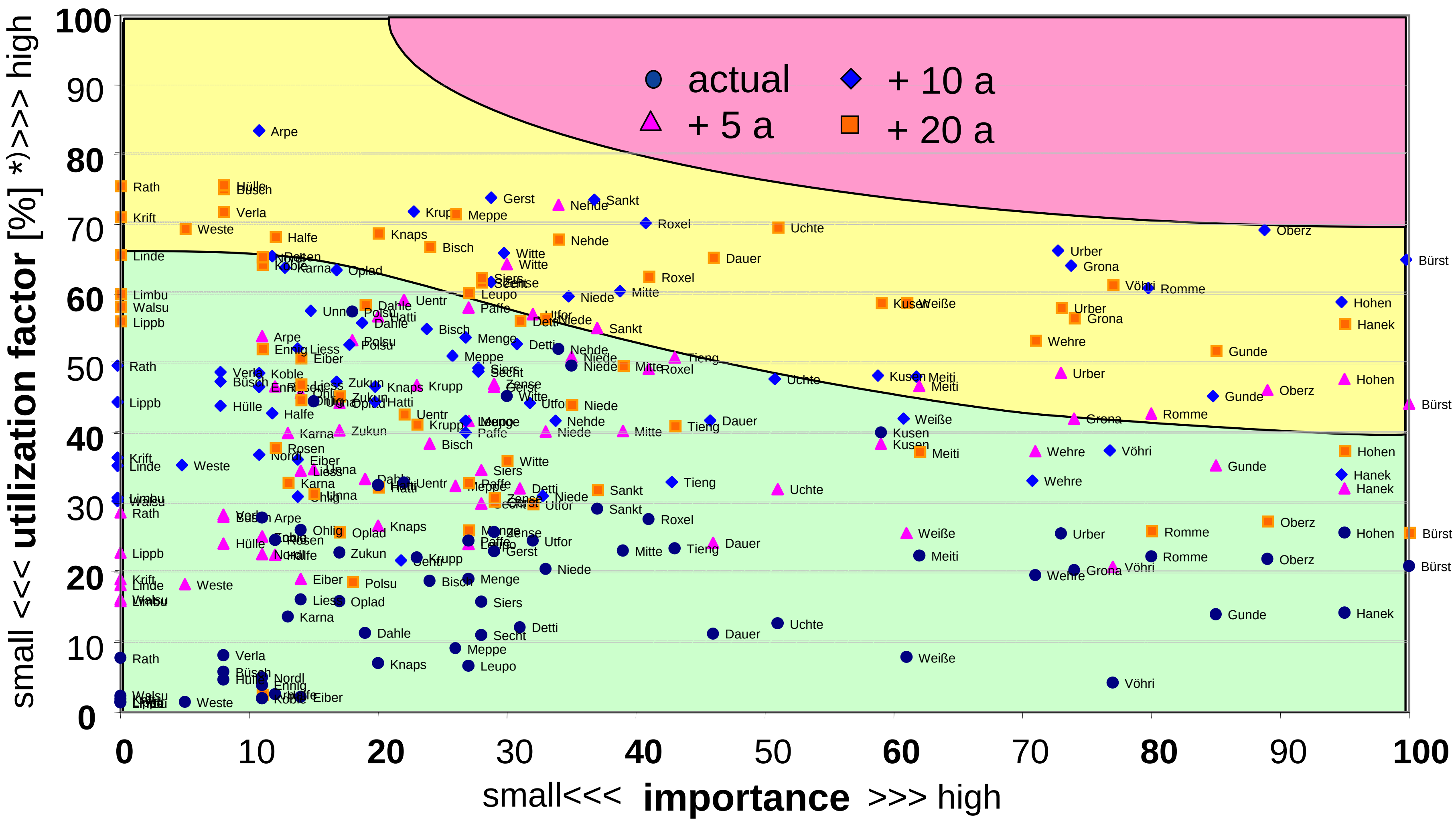
End of life prognosis due to knowledge of the basic ageing process



*) utilization factor => expected life related to nominal service life

End of service life assessment of 380 kV substations*

(equipment with impermissible utilization factor will be exchanged)



Conclusion

- For support of the decision making process for substation renovation the asset management needs simple, but technically justified and effective method for assessment

–**of actual conditions of the equipment**

–**end of equipment life**

- Methods and algorithms described provide qualified information

– **for determining near-term action and annual business planning**

–**also for forecasting the technical and financial effect due to system ageing.**

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Thanks for Your attention!

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