



# Energy Infrastructure Risk Mitigation with Progress<sup>®</sup> Corticon<sup>®</sup>

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# Background

- In the United States, the power system consists of more than 10,000 power plants, nearly 650,000 miles of high-voltage power lines, over 6.3 million miles of low-voltage power lines and distribution transformers.
- Average power plant age > 30 years, 70% at least 25 years in service
- Climate Threats to Electric Infrastructure – temperature, storms, sea level rise...

(Figures via [Wilson Quarterly](#))

# Maintaining Energy Infrastructure

- Quite a complicated exercise to assess and weight risks related to:
  - power equipment degradation
  - Power equipment uptime
  - Importance of each component in a power system for over function
  - Effectiveness and resilience of transmission

(Figures via [Wilson Quarterly](#))

# Power transformers

- Main component of a power system is a power transformer. The high voltage (can exceed 300,000 volts) electricity in power lines is suitable for transmitting power over long distances. For everyday applications, the electricity must pass through a transformer which converts the power to a suitable voltage.
- Transformers “transform” one voltage or current level into another. They increase or decrease the voltage and current levels of their supply, without modifying its frequency, or the amount of electrical power being transferred
- A transformer typically consists of two separate coils with different numbers of turns of conductor wound around the same closed laminated iron core
- Critically, each coil must be insulated to operate safely. Insulation degrades over time and due to many factors.

<https://eepower.com/technical-articles/transformer-operating-principles/#>

# Power transformers Health and Criticality Assessments

- Health index for power transformers:
  - Evaluation of technical aspects (Probability of occurrence of a failure that compromises the availability of the unit)
  - Consequences caused by unavailability
- Criticality Assessment: Relative importance of an event (e.g. a failure of a transformer) in different situations, that make the replacement of a failed transformer easier, or more difficult, depending, for example,
  - availability of a spare transformer to replace the failed one
  - the difficulty to move the transformer due to its dimension
  - the difficulty of the repair due to problematic accessibility
  - unavailability of pieces to make the repair

- *Energies* 2023, 16, 4448. <https://doi.org/10.3390/en16114448> <https://www.mdpi.com/journal/energies>
- M. Augusta Martins / *Ciência & Tecnologia dos Materiais* 26 (2014) 9–16

# Health Components

## Probability

- Operating history (overloading history)
- Failure history of “sister units”
- Oil testing history/Paper tests – Actual condition
- Operating environment (exposure to system faults external to the transformer).
- Manufacturer (design, materials, standards used by the manufacturer and level of expertise and experience of people involved in the construction process).
- Age and service time that may affect mechanical strength, and so the ability to withstand short circuit forces, usual in a transmission/distribution system.

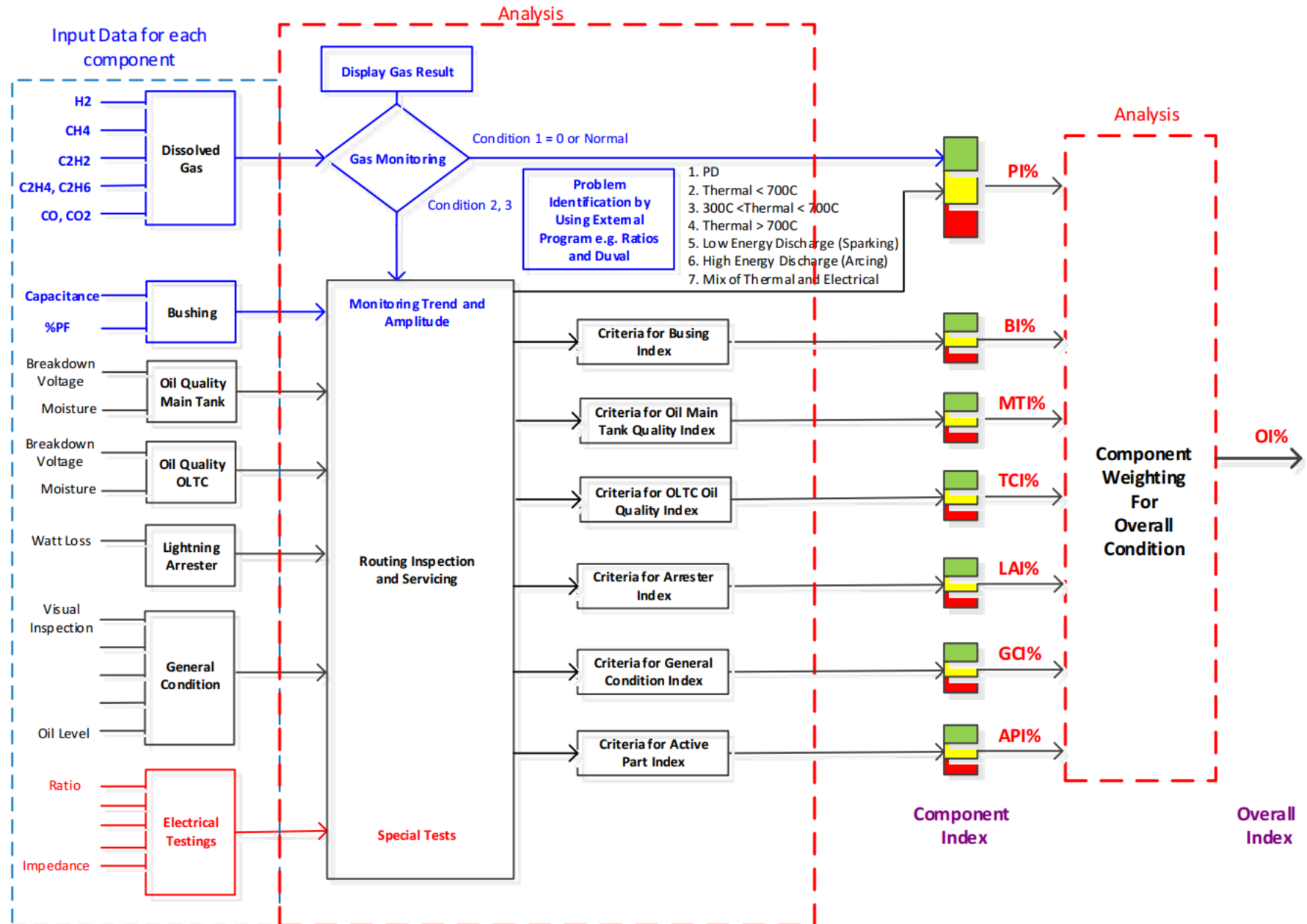
## Consequence

- Undelivered energy
- The maximum loss (cost of repair, considering also the availability of spare parts, that can be used for repair), repair feasibility, or replacement costs, of the complete transformer, environmental and clean-up costs, lost revenues, litigation costs, or any other indirect costs, related on the transformer failure.
- The strategic impact of the transformer (for example: existence of critical customers and impact of loss of reliability).

# Criticality Components


## The failure of an asset results in a consequence


- Localized loss of supply
- Wide scale outage
- Near miss fatality
- Importance of energy consumer (water treatment plant, hospital)
- Impact of failure (population center)








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 Rule Vocabulary


∨  Asset


 age\_years


 id

 location


 name


 nameplate\_voltage\_ratio\_decimal


 nameplate\_voltage\_ratio\_string


 total\_inspections


← inspection (Inspection)


∨  Inspection


 date

 net\_condition\_index

 score\_classification

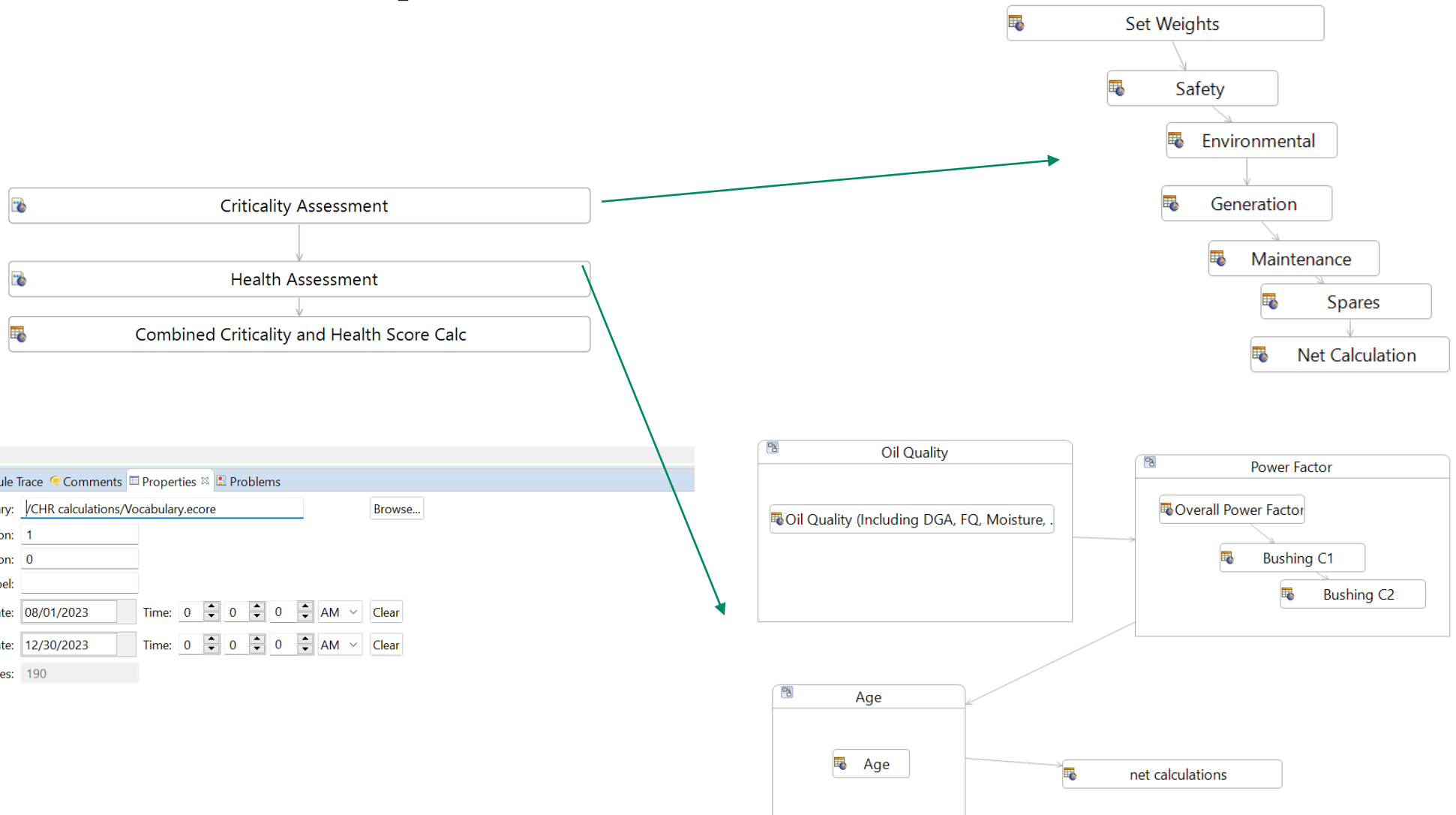
 score\_description

 tier1\_condition\_index

 tier2\_adjustments

➤ asset (Asset)

# Health and Criticality Ruleflow



	Conditions	0	1	2	3	4	5	6	7	8	9	10	11		
a	oil_qual.dga_result		null	-	-	-	-	-	-	-	-	-	-		
b	oil_qual.fluid_quality_results		-	null	-	-	-	-	-	-	-	-	-		
c	oil_qual.furan_results		-	-	null	-	-	-	-	-	-	-	-		
d	oil_qual.moisture_results		-	-	-	null	null	null	null	-	-	-	-		
e	oil_qual.water_content		-	-	-	<= 20	(20..30]	(30..40]	> 40	-	-	-	-		
f	Equipment.health_Calculation.oil_quality_score		-	-	-	-	-	-	-	1	2	3	4		
g															
h															
i															
Actions															
Post Message(s)		✉	✉	✉	✉	✉	✉	✉	✉	✉	✉	✉	✉		
E	Equipment.health_Calculation.oil_quality_score	(Oil_Quality_Assessment.dga_result + Oil_Quality_Assessment.fluid_quality_results + Oil_Quality_Assessment.furan_results + Oil_Quality_Assessment.moisture_results)/4													
F	oil_qual.score_desc											'Good'	'Deteriora...	'Investigated'	'Bad'
G															
Overrides															

[Rule Statements](#) ✘
 [Rule Messages](#)
[Rule Trace](#)
[Comments](#)
[Properties](#)
[Problems](#)

Ref	ID	Post	Alias	Text
1		Info	oil_qual	Values that are blank for dgaresult_MAIN are assigned a 1
2		Info	oil_qual	Values that are blank for fresult_MAIN are assigned a 1
3		Info	oil_qual	Values that are blank for furansrlt_MAIN are assigned a 1
4:7		Info	oil_qual	When moisture_MAIN is null and water_MAIN is [{Oil_Quality_Assessment.water_content}], assign the value of [{Oil_Quality_Assessment.moisture_results}] to Moisture_MAIN
8:11		Info	oil_qual	Oil Quality Score of [{Equipment.health_Calculation.oil_quality_score}], set score description to [{Oil_Quality_Assessment.score_desc}]
0		Info	oil_qual	Oil Quality Score calculated based upon sum of DGA Result, Fluid Quality Result, Furan Result, and Moisture Result

