X SICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

XSICEL 2021
Transición energética en la 4ta revolución industrial

Power Shunt Capacitor Bank Management Model Based on Life Expectancy and Risk Overtime

Presented by:

Camilo Trujillo A.
M.Sc. Student Politecnico di Milano – Smart Grids

Previous work with High Voltage Innovation Laboratory,
National University of Colombia

Contents

I. Introduction

II. Methodology

III. Technical Model

IV. Economical Model

V. Results and Validation

VI. Conclusions

I. Introduction

Ministerio de Minas y Energía

COMISIÓN DE REGULACIÓN DE ENERGÍA Y GAS

RESOLUCIÓN No. 015 DE 2018

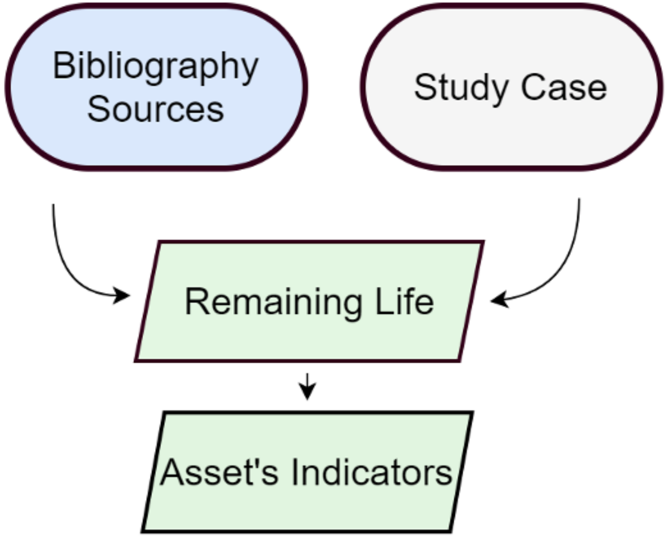
(ENE.29-2018)

Por la cual se establece la metodología para la remuneración de la actividad de distribución de energía eléctrica en el Sistema Interconectado Nacional

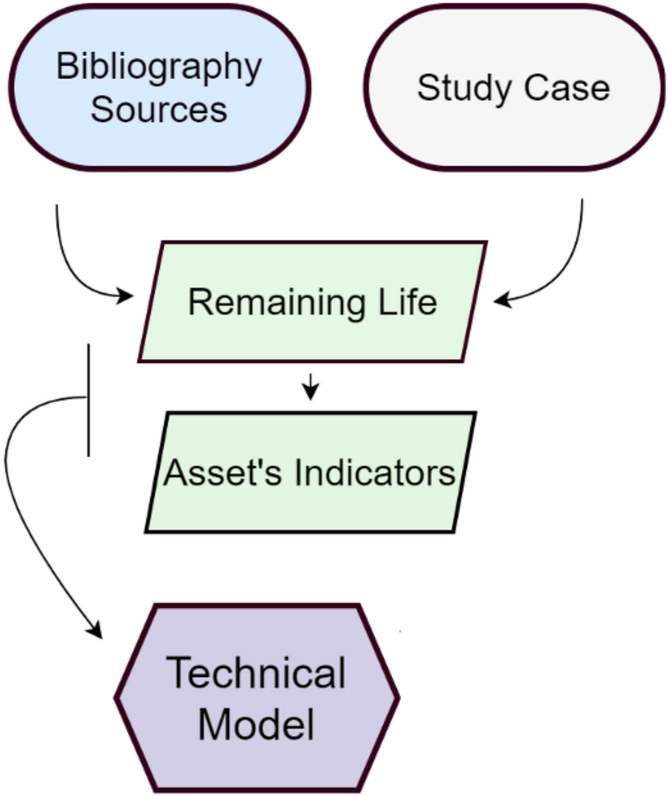
https://iso.org

https://electrical-engineering-portal.com

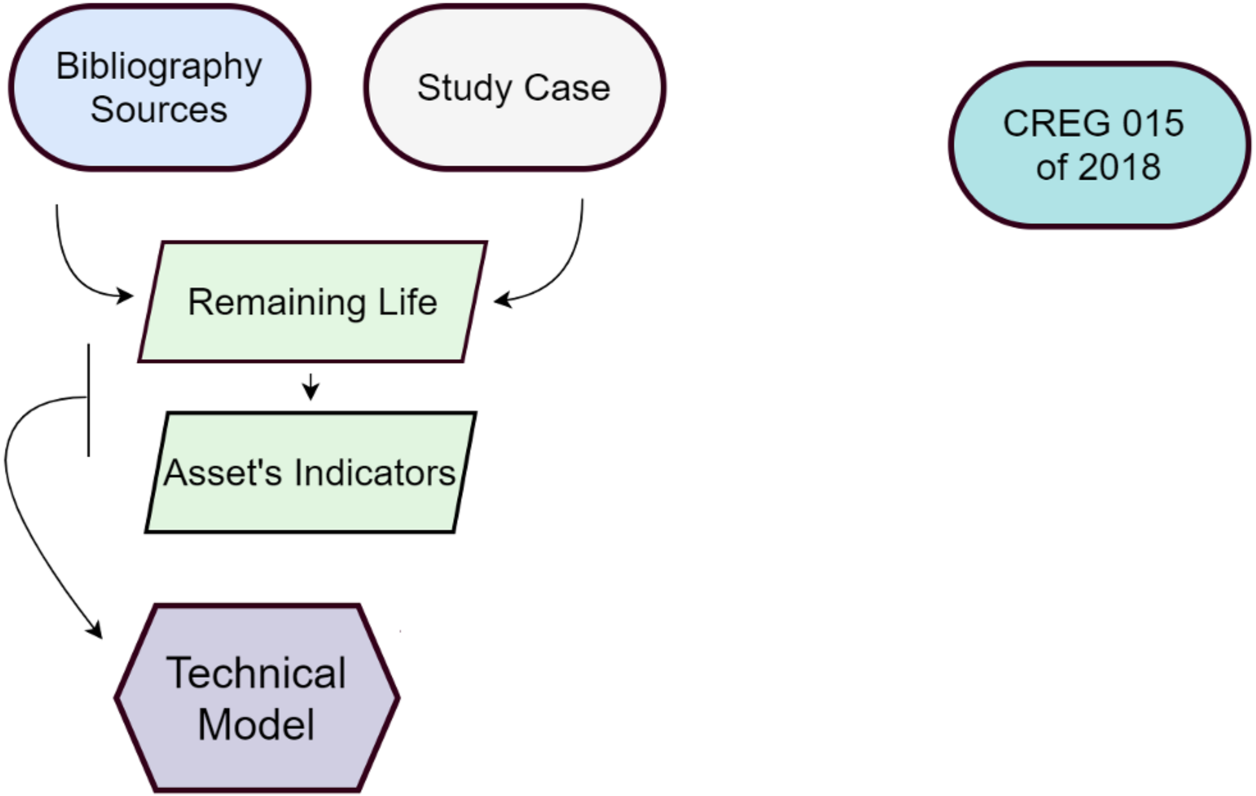
II. Methodology



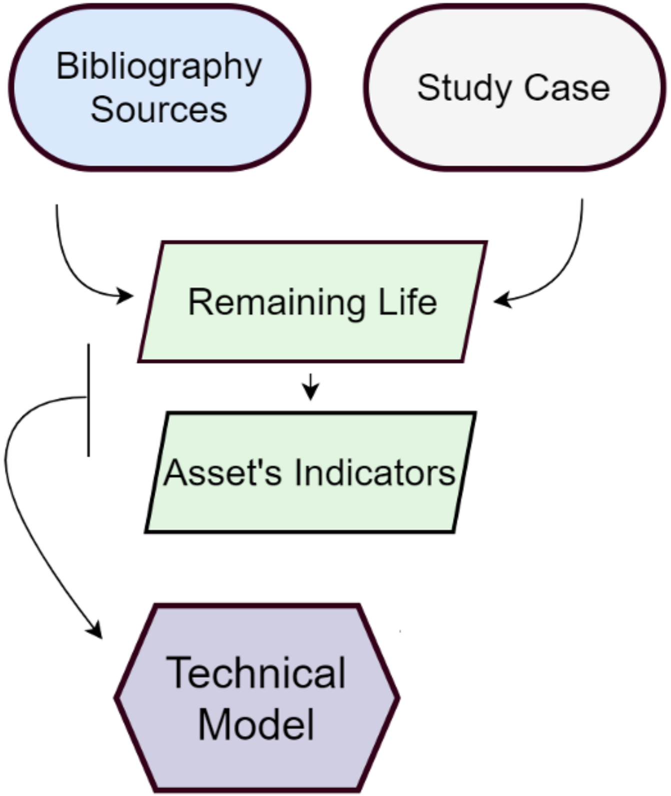
II. Methodology

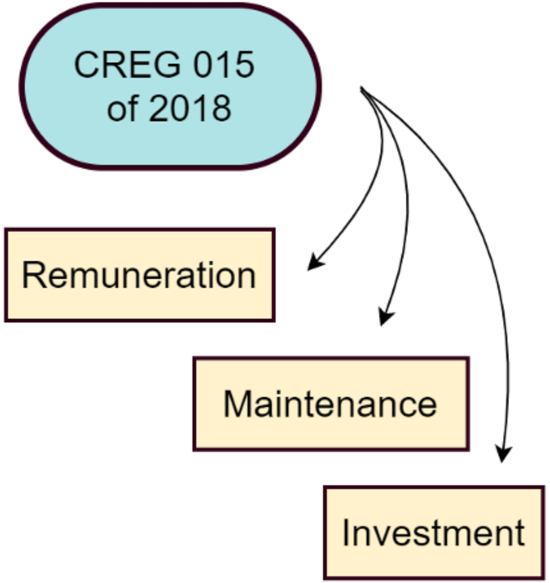


II. Methodology

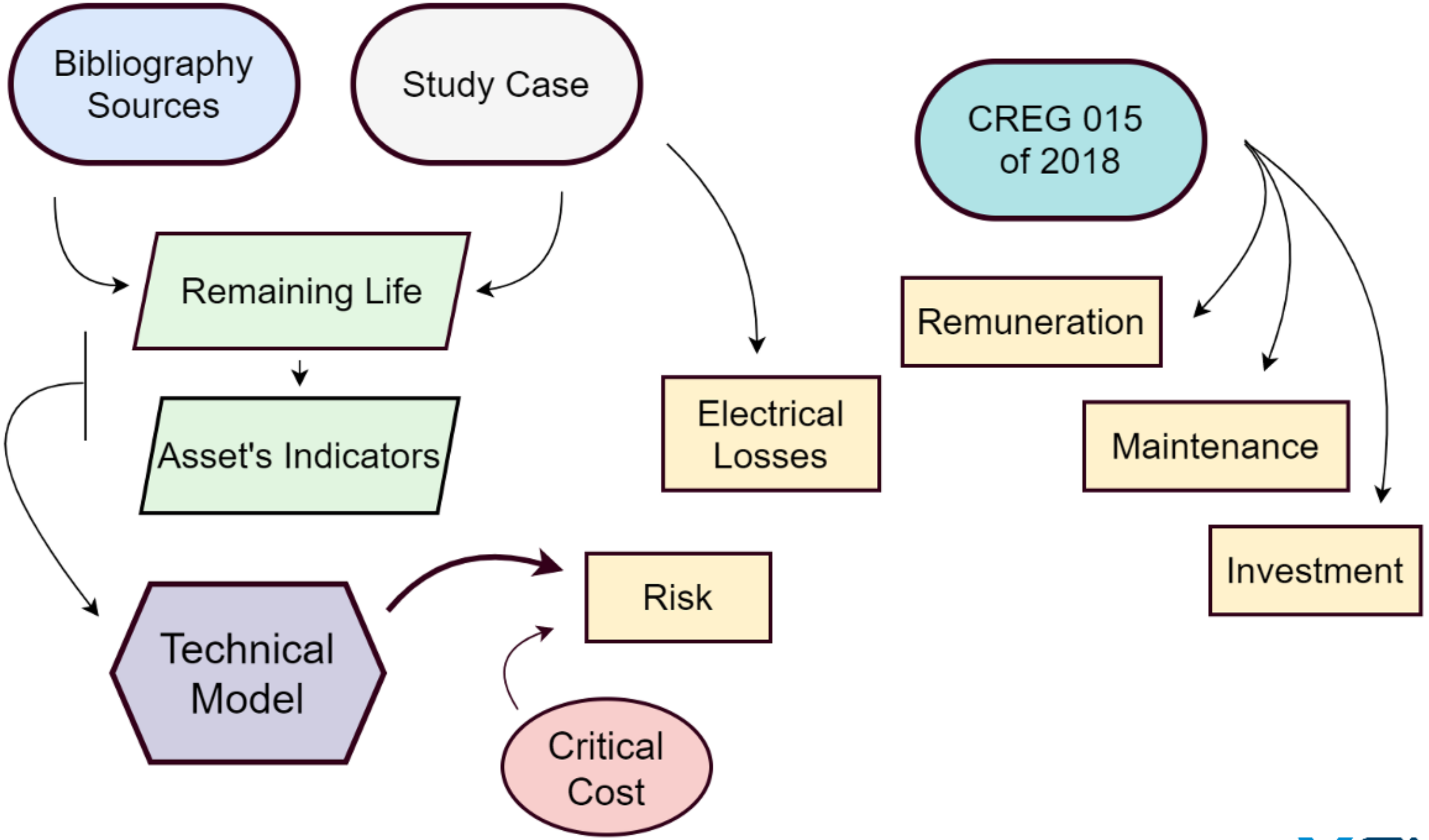


II. Methodology

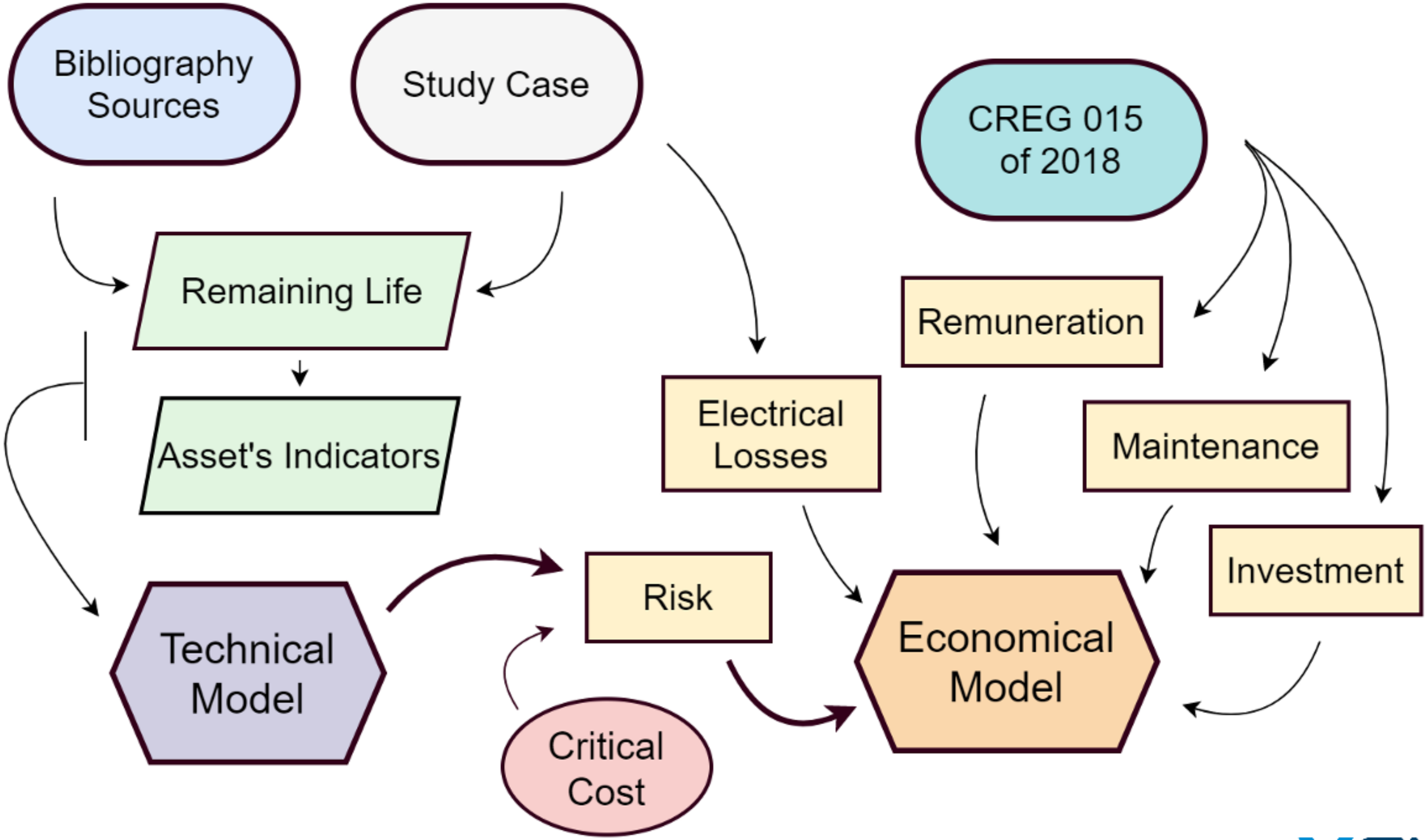




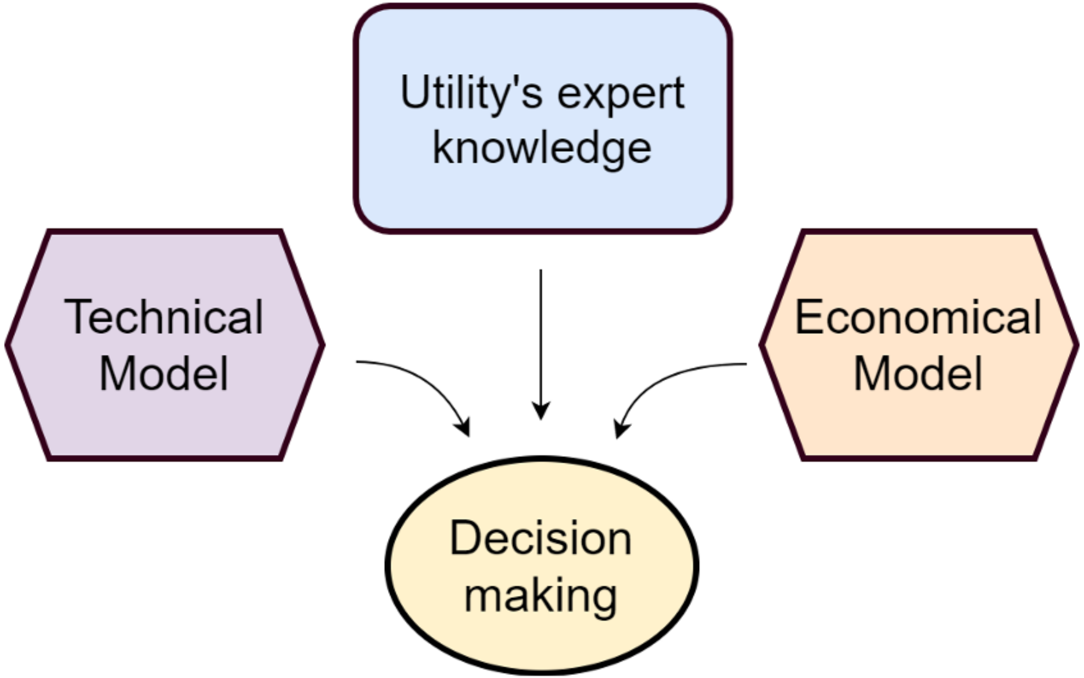
II. Methodology



II. Methodology



II. Methodology



II. Technical Model

Remaining Life can be estimated through the operation conditions

$$L = \frac{L_0 \cdot k_u}{k_f^{0,81} \cdot k_p^{5,33} \cdot k_{rms}^{1,96}}$$

III. Technical Model – RL computation

k_p

Rate between Voltage nominal and real peak value, times $k_{1,16}$

$\mathrm{k_{rms}}$

Rate between Voltage nominal and real RMS value, times $k_{1,16}$

k_f

Harmonics Incidence factor

$$L = \frac{L_0 \cdot k_u}{k_f^{0,81} \cdot k_p^{5,33} \cdot k_{rms}^{1,96}}$$

$k_{1,16}$= 1,16 (Includes what is exposed in IEEE 1036)

k_u = Use factor (% of monthly operation)

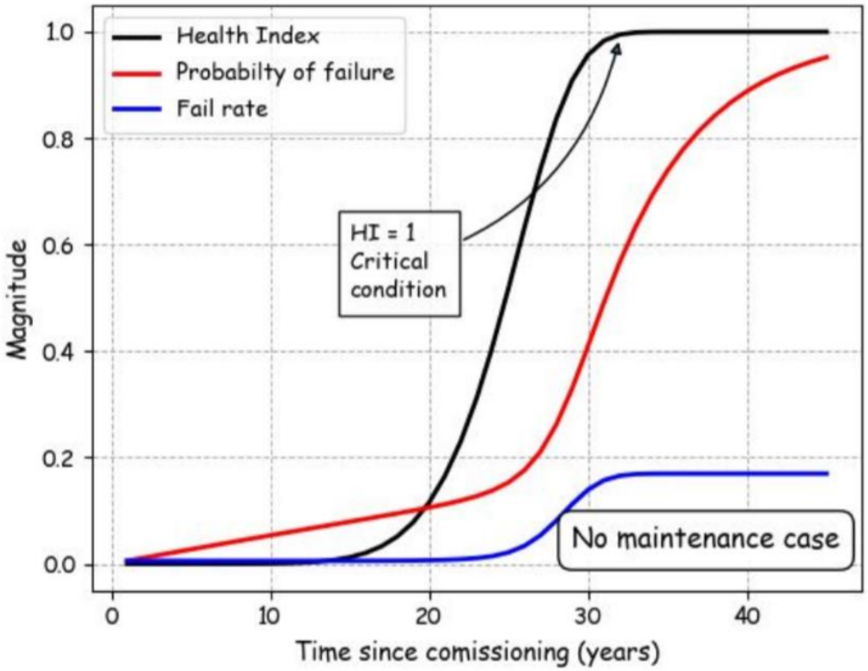
L_0 = Pre-defined useful life (given by manufacturer)

17% Error margin

Taken from: [1-3]

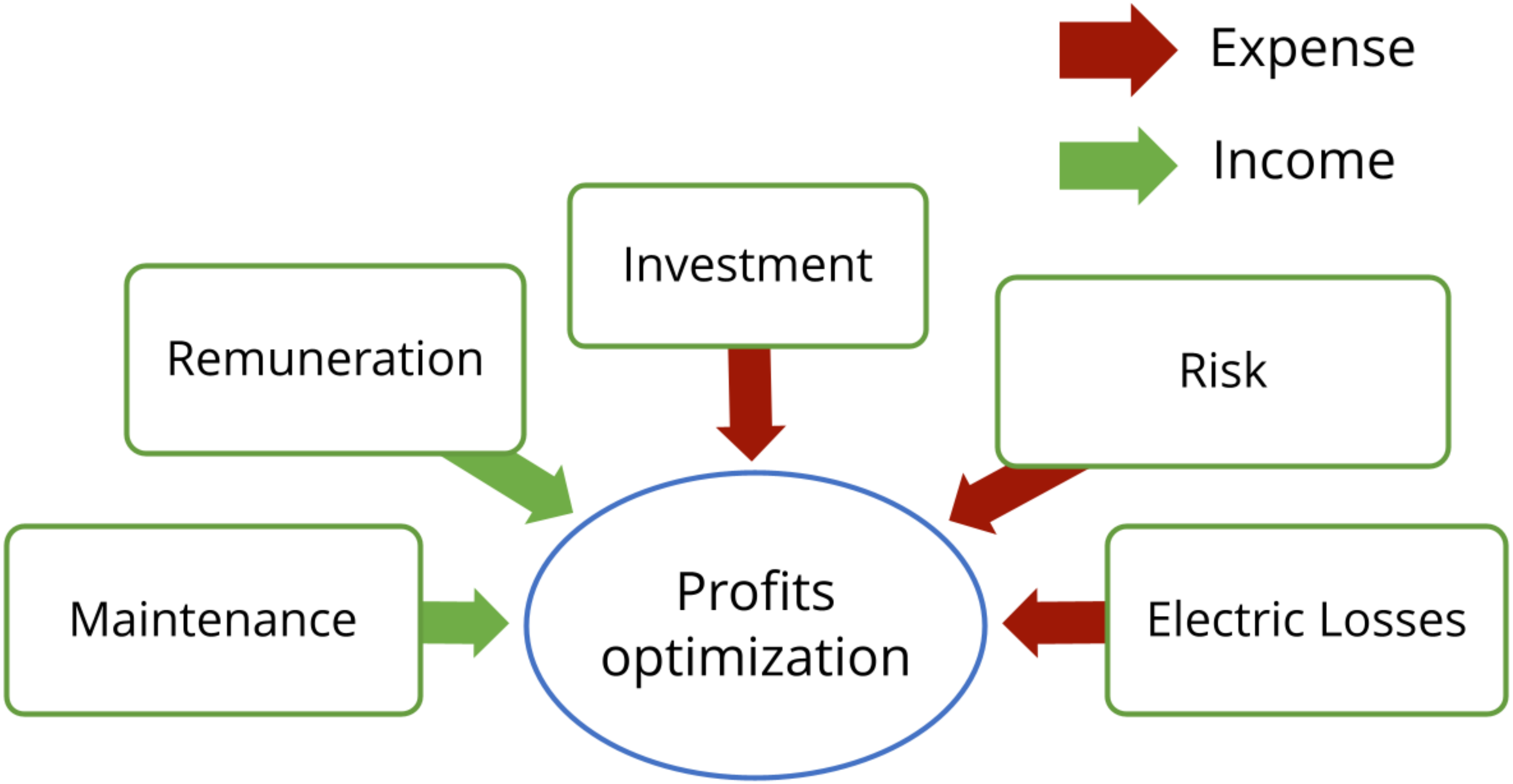
III. Technical Model – Indicators

Health Index (HI)	$HI(t) = 0{,}01e^{-(t/26)^{10}}$
Failure rate (λ)	$\lambda(t) = 0{,}0016e^{4{,}67HI(t)} + 0{,}004$
Reliability (R)	$R(T) = e^{-\int_0^T \lambda(t)\,dt}$
Probability of failure (POF)	$POF(T) = 1 - R(T)$



Taken from: [6-10]

IV. Economical Model



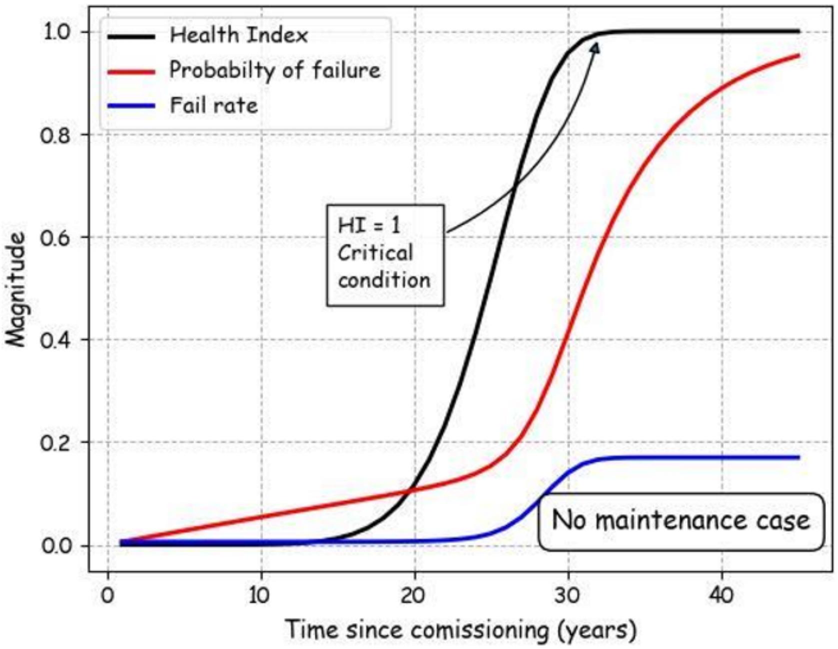
V. Results and Validation

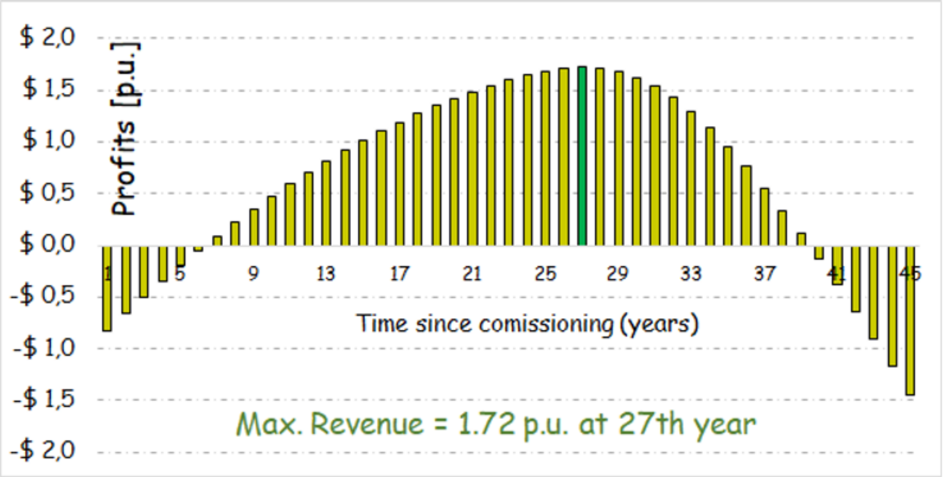
Consider the following ideal (no accelerated degradation) and real case with:

Capacitance	9,02 uF	**Harmonic's Order & Magnitude**	5 to
Operation Voltage	125 kV		20% V
Design Voltage	135 kV	**Losses**	0,05 W/kVAr
Power	45 MVA	**Dielectric**	Edisol VI
Useful Life	30 years	**Use**	50%/month

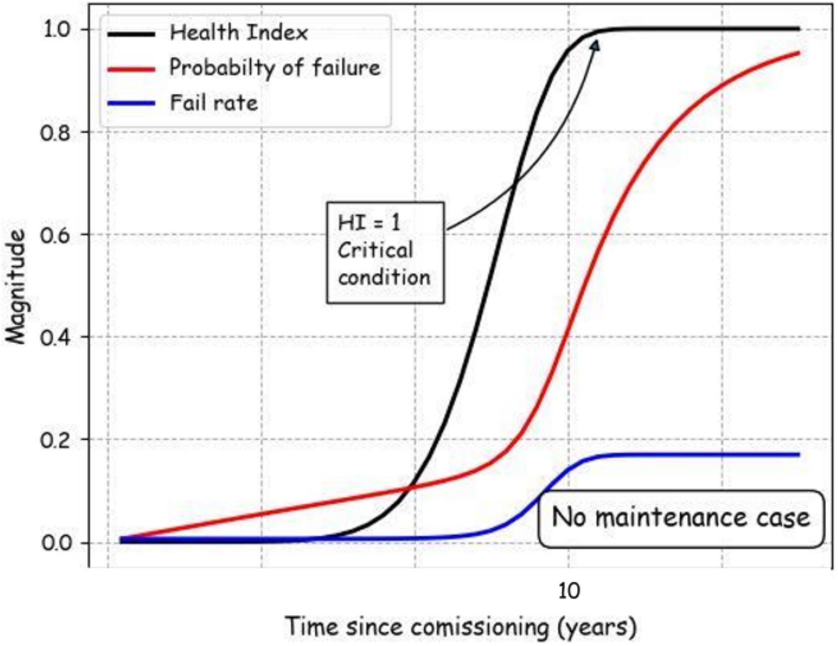
MVAr	$ 590,8	**Critical cost**	0.3 pu
Instalation	$ 73,6	**Losses**	0.008 pu
IC	$ 665 (1 p.u)	**ri**	12 %

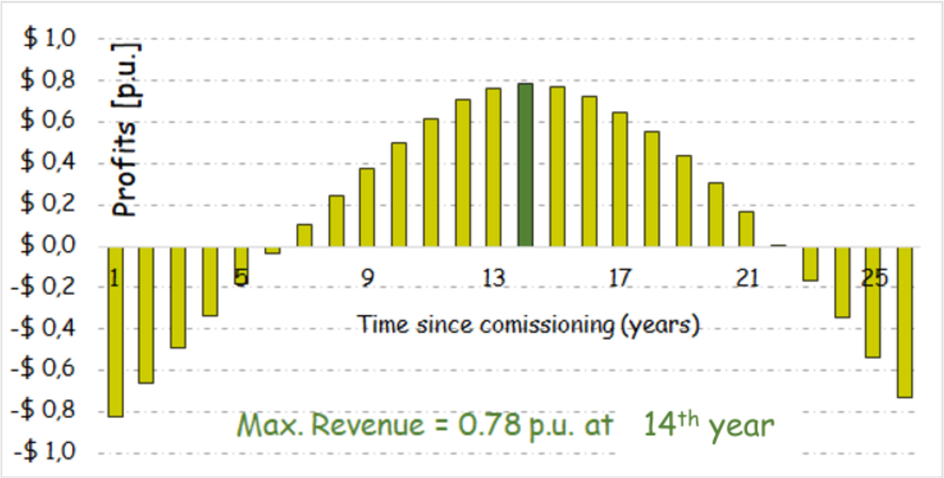
Ideal Case
(No Accelerated degradation) No maintenance



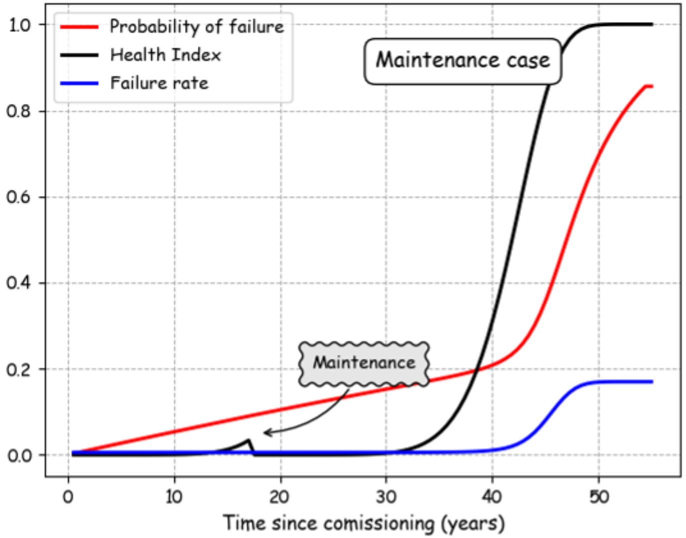


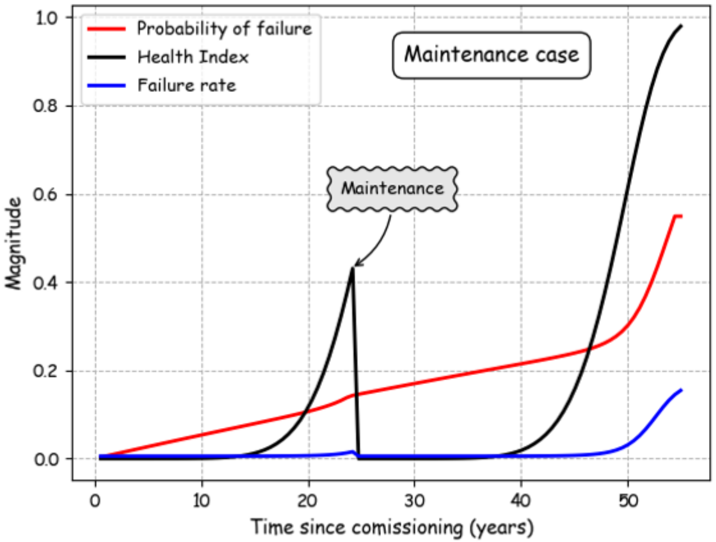
Real Case
(Accelerated degradation) No maintenance





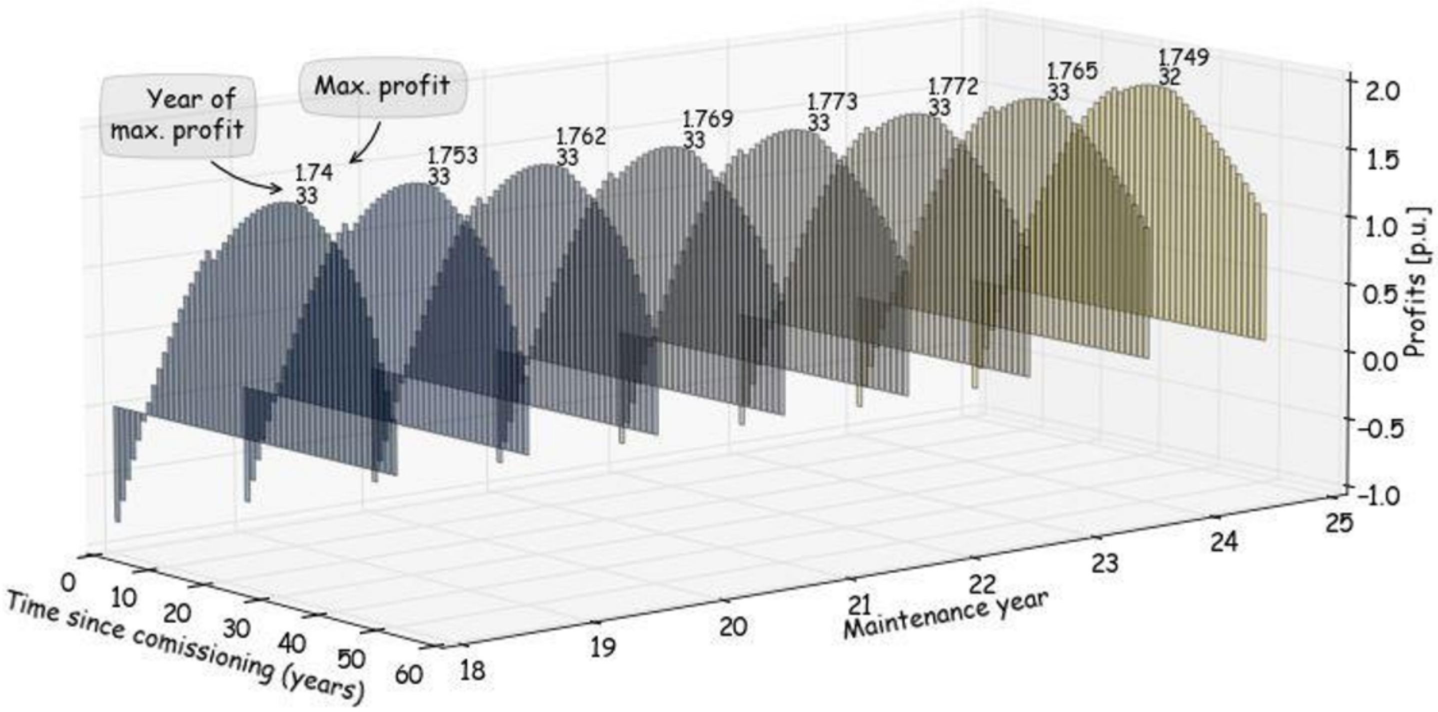
Ideal Case
(No Accelerated degradation) With maintenance



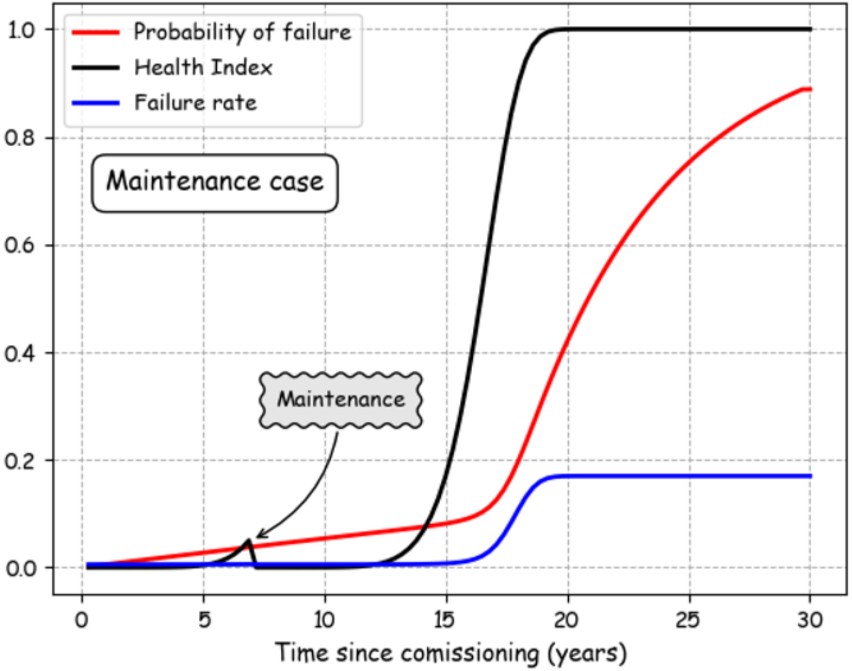


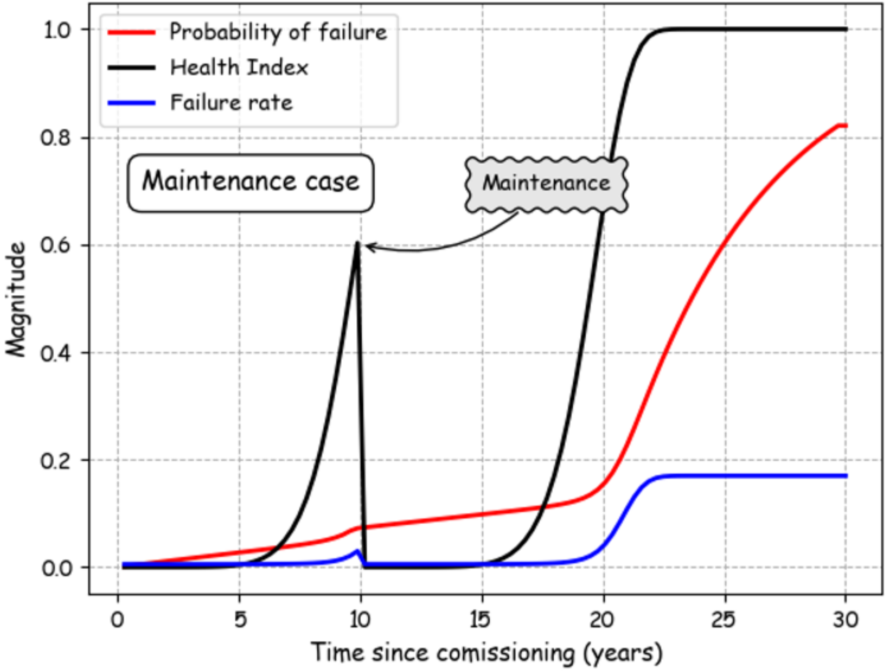
When is the optimal maintenance?

Ideal Case
(No Accelerated degradation) With maintenance

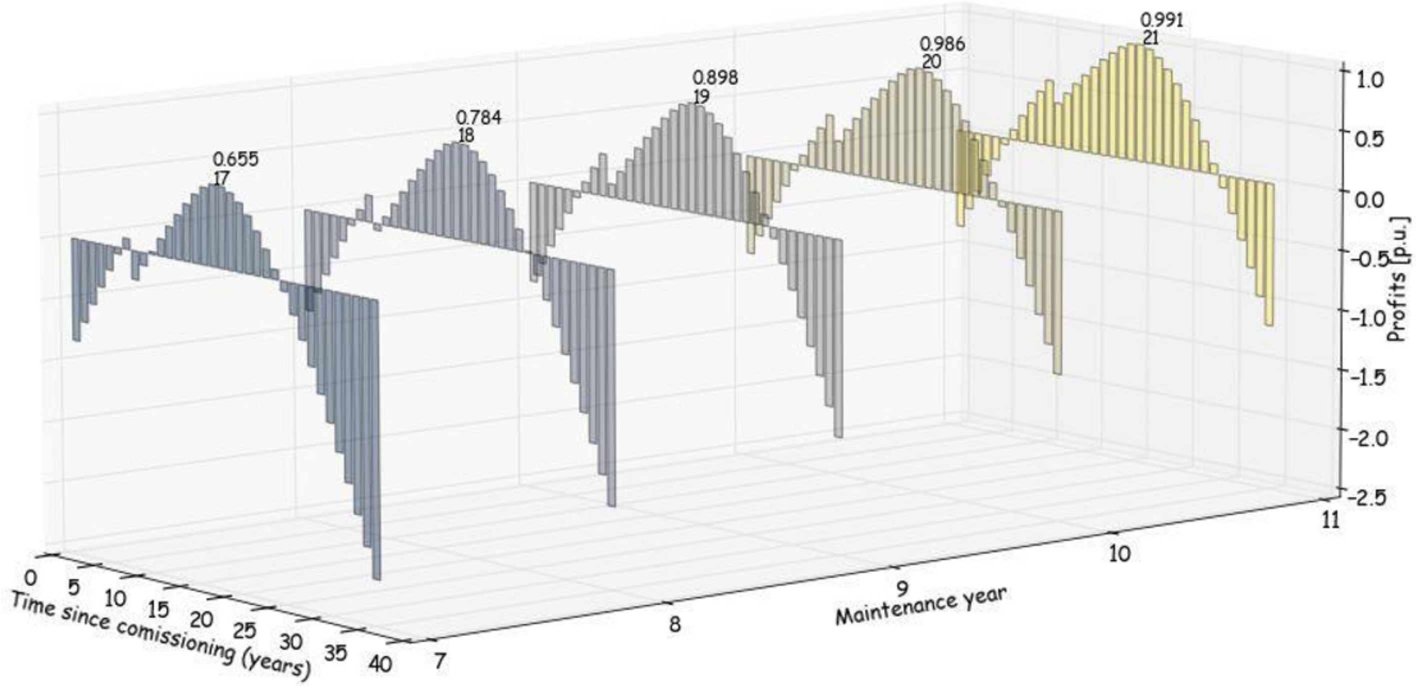


Real Case
(Accelerated degradation) No maintenance





Real Case
(Accelerated degradation) No maintenance



VI. Conclusions

- Models presented can improve maintenance strategies and boost capacitor’s bank performance.
- On ideal conditions, maintenance increase capacitor’s bank life but it does not improve significantly revenues.
- In order to improve the results, it is necessary to adjust the constants of health index and failure rate. Also, the economic variables.

References

1. G. C. Montanari I., D. F. (1998). "*Searching for the factors which affect self-healing capacitor degradation under non-sinusoidal voltage*". IEEE.
2. G. C.Montanari I., D. F., Ghinello. (1999). Accelerated degradation of capacitor pp films undervoltage distortion. IEEE Transactions on Dielectrics and Electrical Insulation.
3. IEEE. (2010). 1036 ieee guide for the application of shunt power capacitors.
4. CREG. (2018). Resolución no. 015 de 2018: Por la cual se establece la metodología para la remuneración de la actividad de distribución de energía eléctrica en el sistema interconectado nacional.
5. Enel-Condesa. (s.f.). Informes internos.
6. DHILLON, B. (1999). Topics in Reliability. *Engineering Maintainability*, 224–249. doi: 10.1016/b978-088415257-6/50012-0
7. H. N. Nagamani, S. G. (1992). A study of electrical endurance of mppf capacitors and selection of end-point criteria. IEEE.
8. H. N. Nagamani, S. G. (2014). Transformer health status evaluation model based onmultifeature factors. Proceedings of the 2014 international conference on power system technology (POWERCON 2014), 1417–1422.
9. Manling Dong, H. Z. (2019). A novel maintenance decision making model of power transformers based on reliability and economy assessment. IEEE Access.
10. R. E. Brown I., H. L.W., G. Frimpong. (2004). Failure rate modeling using equipment inspection data. IEEE TRANSACTIONS ON POWER SYSTEMS, 19(2).

Thank you for your attention

Questions?