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A Literature Survey on Different Transformer Techno Economical Life Cycle Analysis

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Abstract— Transformer is one of the important part of electrical engineering. Therefore life cycle of the transformer an emerging topic in electrical industry. In the last decade there are different research work present in the this field, they predict the techno economical cost and life cycle of transformer. In this research work proposed modified objective function based techno economical cost analysis of transformer. The modified objective function is simulated on the matrix laboratory. The simulated outcome shows the better accuracy in life cycle calculation of transformer as compare to other previous methods.

***Keywords*—Transformer, Total Owning Cost, Life Cycle and Object function etc …**

I. INTRODUCTION

The distribution transformer is the most important single piece of electrical equipment installed in electrical distribution networks with a large impact on the network's overall cost, efficiency and reliability. Selection and acquisition of distribution transformers which are optimized for a particular distribution network, the utility's investment strategy, the network's maintenance policies and local service and loading conditions will provide definite benefits (improved financial and technical performance) for both utilities and their customers. Many electrical distribution utilities claim that they purchase distribution transformers using some type of loss evaluation procedure. Over the past 25 years, these purchasing practices have been established, as the utilities have apparently become aware of the range and the value of distribution transformer losses. On the other hand, very few industrial and commercial customers include evaluation of distribution transformer losses in the purchasing process. proposed an evaluation technique from the industrial and commercial customers' point of view. Moreover, the expected large increases in energy demand and the need to undertake effective measures to protect the environment could be partially solved by improvements in energy efficiency of distribution transformers. Optimized distribution transformers (cost-effective and highly efficient designs) would provide numerous global benefits to the wider public as well as local benefits to electrical distribution companies, their customers and other users of distribution transformers.

II. LITERATURE REVIEW

Niu, Xin,et.al (2023) - Author are presented the predictive maintenance method based on the retrogression analysis of equipment service age can calculate the failure probability before and after maintenance and can be used to flexibly formulate maintenance strategies to reduce operation and maintenance costs and improve long-term benefits. This method comprehensively analyzes the change and cost effectiveness ratio of substation EENS and equipment LCC before and after different maintenance schemes, and then overcomes the contradiction between cost and long-term benefit on the premise of controlling power supply risk, and selects the best maintenance strategy according to the principles of reliability priority, economy priority and cost effectiveness priority. Among them, the service age regression factor can be used to quantitatively describe the repair effect of service age on equipment performance, and the decision results in the example analysis verify that the cost-effectiveness ratio priority strategy can take into account both reliability and economy [01].

Campanhola et.al,(2023) - They are presented it can be concluded that the article fulfilled its objective by proposing a methodology for analysing the costs of the unavailability of large power transformers due to the overload caused to the other transformers in the network. This methodology presented can be used as a tool to aid decision-making in the management of equipment by the power utilities. Likewise, it helps to bring to light financial data that, together with the power utilities' technical and strategic parameters, can form an important decision making tool for proper prioritization when replacing equipment or reconfiguring the system. As a limitation, this case study was carried out in a single power utility, and it can be expanded to the complete network through the availability of data and computational capacity to perform the simulations [02].

Cossutta, et.al,(2022) - Author are study trade-offs exist between electricity supply costs, peak reduction and life cycle GHG reductions. PV generation provides a significant reduction in GHG emissions, but makes little contribution to reducing peak demand from the grid. Community energy storage in batteries are effective at reducing peak demand, but at significant additional costs, and may result in a modest increase in GHG emissions due to emissions associated with battery manufacture. GHG emissions reductions with community-level energy storage would be possible, provided that they are charged with renewable (or low carbon) electricity sources and discharged at times where fossil fuel generation can thereby be avoided, but analysis of such a management strategy is outside of the scope of the current paper. Anticipated cost reductions for PV and battery, and longer battery cycle life, will considerably reduce the cost of community electricity generation and storage for managing peak grid demand [03].

Chen,et.al,(2023) - They are presented a techno-economic framework for the evaluation and comparison of different power distribution architectures in large-scale data centres. The technical indicators such as LOLE, equipment damage risk, and system efficiency are calculated and mapped to the economic metrics. Numerical results show that using a DC system at the medium voltage level can substantially reduce the costs of data centers as compared with the conventional AC architectures. It is concluded that the LVDC and MVDC architectures enhance the system efficiency at a lower cost. The highest overall performance is observed in the MVDC architecture that employs WBG devices [04].

Rinaldi,et.al - (2021) - framework for the techno-economic characterisation of floating offshore wind projects exploiting the use of detailed operation and maintenance models is presented. As shown, this can be effectively employed in order to tackle some of the existing challenges for this novel technology, especially in terms of reducing the uncertainty in the estimation of the project key performance indicators. This, in turn, allows to increase the confidence in the viability of a project. One of the objectives of this work was to demonstrate the added value of using an accurate and specific operation and maintenance model to reduce the number of assumptions in levelised cost of energy estimations. This is demonstrated by comparing the results obtained with the presented framework with those previously obtained in literature, as well as by analysing the variance of the project costs based on the variability of parameters such as annual energy production and operational expenses, and showing the differences that would be obtained with simpler approaches. While the accuracy of both estimations (the ones presented in this work and those found in literature) is not compared, due to the impracticalities in lack of validation against a real scenario, the advantages of considering and estimating more key performance indicators (e.g. contribution to downtime and costs of repair or replacement of individual components) is shown. The transparency of the calculations is improved, and the uncertainties inherently linked to the operation of a given wind farm captured. In this way a better understanding of the validity and variability of the estimations is achieved **[05].**

Nömm et.al - (2021), Researcher investigated the IRs related to consumption changes for two different SMG design strategies, one with the objective to provide the lowest LCC (HR-SMG) and the other to provide a lower IR for a SMG (LR-SMG). The IR for both was then compared with a CGC. In this study, an increase in AEC was the largest IR factor for both a SMG and CGC since an increase in AEC could increase the LCC more than an adverse change in CP. A potential increase in EC was the largest IR factor of the AEC since the LCOEE was several times larger than the LCOH in the modeled SMG and therefore any increase in EC would increase the LCC more than an equal increase in HC. This study concurs with previous literature that the variability of the AEC constitutes an IR of a SMG [9,10] and has added the information that an increase in AEC is a larger IR factor than an adverse change in CP for a SMG. A change from 1 to 100 MWh of AEC constituted an increase in LCC of 125.1%–175.5% for a HR-SMG and 48.8%–65.3% for a LR-SMG for the investigated locations. This increase could happen if for instance three summer house customers with 1 MWh of AEC becomes three all-year residents with 100 MWh of AEC. An adverse change in CP could increase the LCC of a HR-SMG by 21.9%–22.9% and 6.2%–8.7% for an adverse change in TOC for the investigated locations. The LR-SMG had a maximum increase of below 1% for all locations for adverse changes in CP. The average value for an LCC increase due to an adverse change in CP was below 1% for both SMG design strategies which shows that the majority of the measured CPs does not contribute to a significant increase in IR for a SMG. The LR-SMG reduced the average IR for an adverse change in CP by over 96% and 45.5%–49.5% for an AEC increase but with an increase in average BEMVLL of 62.9%–70.9% in comparison to a HR-SMG. This shows that there is a clear tradeoffs between economic opportunity and IR for the two SMG design strategies. SMGs in locations with larger overall AMCF for SP and WT had a lower IR for a potential AEC increase which was mainly attributed to lower diesel fuel dependence as the AMCF increased. The CGC had a 100% lower average IR than a SMG for an adverse change in CP since the cost of electricity was not time varying for a CGC and because the CGC was dimensioned to handle all PCs within the defined fuse size. The CGC had a 23.6%–42.6% lower average IR than a LR-

SMG for an increase in AEC since the annual electricity production cost was the only cost variable that could increase for a CGC, since the capital and maintenance costs of a CGC was related to a fixed MV line length. However, if the distance to the customers from a MV PCC is larger than the BEMVLL, a SMG could still be more economical than a CGC even if the SMG LCC would increase due to an AEC increase and/or adverse change in CP, since the SMG LCC could still be lower than the CGC LCC [06].

Beltran,et.al - (2020) After analyzing the power and energy capacity requirements for an ESS implemented at a wind turbine or at a wind farm level to provide IR and FS services, this paper reviewed and discussed the different technologies available in the industry that could comply with these requirements. As well as identifying prospective storage technologies, two control strategies were identified that are capable of providing the specific inertial response characteristics, but may require further adjustment depending on the final technology choice e.g., considering state-of-charge of the storage system. Out of the multiple ES technologies compelled in the literature and taking into account various constraints (location-dependence, maturity, technical characteristics), three are considered as potential candidates: flywheels, super capacitors, and three chemistries out of the Li-ion battery family (NMC, LFP, and LTO). The three technologies are then described and evaluated from a technological and industrial point of view. Finally, they are compared in terms of physical constraints (volume and weight), expected lifetime, and cost. For such a specific application, none of them are found to be clearly superior to the others and commercial systems will have to be optimally adapted and tailored to the different requirements dependent on the amount of inertia, maximum RoCoF, and maximum frequency deviation to be allowed. It is also important to take into account if the energy storage system is only used for IR service or also for FS or even primary frequency control. In the first case, the high power intensive requirement indicates SC solutions to be the most suitable technology while, in the latter cases, both LiBs and FESSs are superior to SCs [07]

Marchi, B., Zanoni, S., Mazzoldi, L., & Reboldi, R. (2016) Steel industry is one of the largest energy consumers in the manufacturing sector, even though many improvements in the energy efficiency have already been introduced in the Electric Arc Furnace (EAF) process. Consequently, further developments in the energy performance are still requested. However, additional technical and technological progresses are now uneconomical, i.e. high costs for few benefits. The main opportunity consists, thus, in the improvement of the EAF transformer's performance, as its relevance due to the fact that all the melting energy passes trough it. Recent EAF transformers have become indistinctly well performing in terms of rated performances. As a consequence, the basis of the competition has been shifted from the single product to a customized solution, consisting of tangible products and intangible services designed and combined to fulfill specific customer needs in an economical and sustainable manner (PSS). The intangible value is currently the key to obtain competitive advantages and to overcome the competitors' performances. These extra services take into account the real energy losses obtained during the operation of the furnace in order to design a tailor-made transformer, the provider consultancy on the efficient operation of the product and the integration of maintenance initiatives. To perform the economical analysis of the solution, it is thus necessary to calculate the EAF transformer's life cycle cost (LCC) taking into account the purchasing price, the costs of energy losses (no load, load, LV terminals and auxiliary losses) and the cost due to maintenance. At the present, no works have been conducted on the EAF transformers, which are exposed to more critical conditions than power/distribution transformers [08]

Zakeri, B., & Syri, S. (2015) The LCC of different grid-scale EES technologies were analyzed by conducting an extensive review of the existing literature, considering uncertainties in cost data and technical parameters. The results reveal that the cost estimations/projections of the EES systems are rather dispersed and inconsistent among different references. The cost estimations rely on assumptions and scaling the size, the case for most of battery systems, which reduces the consistency among different sources of data. Most of the EES systems are in formative stages of commercialization and those commercial plants are mainly site-specific resulting in more inconsistency in the cost data. Hence, a robust LCC analysis should account for the uncertainties [09]

Lazari, A. L., & Charalambous, C. A. (2015) This paper has introduced a method for evaluating the losses of transformers serving large-scale PV applications. The method is proposed separately for IPPs and for RUs. Under each of the two cases, the capitalization of losses accounts for the appropriate capital and future operating costs of the transformer over its lifetime brought back into a present day cost. The specific operational characteristics of a PV plant have been integrated in the proposed method through two operating states (GS and NGS). A further element that influences the proposed loss evaluation method is the fact that the losses in these transformers will be served locally by the PV plant, rather than remotely by any other generation facilities. Hence the LCOE for PV generation is utilised to estimate the cost value of the energy that will be used by the losses of the transformer. Furthermore, it is clearly demonstrated that under certain conditions, the TOC of the transformer serving a PV system can vary depending on which method of loss evaluation is employed. Finally, it is shown that the annual solar potential has an impact on the loss factors calculation. This is a feature that should be properly accounted for, as it may affect the tender evaluation processes to select the transformer that has the lowest TOC over its lifetime [10]

III. TECHNO ECONOMICAL COST AND OBJECT FUNCTION

The Life-Cycle-Cost Method The Method for Life-Cycle Cost calculation in this paper is performed in accordance to IEC 60300-3-3 “Dependability management Part 3-3: Application guide – Life cycle costing. According to IEC 60300-3-3, the life cycle of an element will be sub-divided into the following six cost-causing phases:

a) Concept and definition;
b) Design and development;
c) Manufacturing;
d) Installation;
e) Operation and maintenance;
f) Disposal.

In many cases it makes sense to combine the fore mentioned different elements of costs into: *ƒ*

- investment, *ƒ*
- operating, *ƒ*
- Recycling costs.

The investment costs (concept/definition, design/development, manufacturing, installation) are in return to the operating costs (operation, maintenance), costs, whose level is visible before the investment is made. In case of the installation costs these costs can be counted to the investment or the operating costs. For a more precise cost assessment, a further distinction between operational and maintenance costs has to be made. Such a distinction allows an easier benchmarking of different maintenance strategies, as these turn out to be the main cost drivers for the analysis.

IV. CONCLUSION

In this survey paper discus the different techno economical factor analysis. This paper defines a probabilistic, life-cycle loss evaluation method for power transformers obliged to serve an intermittent energy source with varying operational and financial characteristics. The associated formulation process renders itself relatively simple and sequential. The formulation relies on data that most independent power producers retain, by virtue of their business evaluation plans, thus making the application of the proposed loss evaluation method attractive. An important conclusion highlighted in the paper rests with the immense influence of the wind potential on the TOC evaluation of power transformers exclusively serving wind plants.

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