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Transformers Improvement and Environment Conservation by Using Synthetic Esters in Egypt

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Abstract: Distribution transformer (DT) is a crucial component in power systems as it exchanges energies between different voltage levels or between utility grid and DC microgrids. Nevertheless, the operation of an oil-immersed DT is limited by the thermal and electrical capabilities of the internal insulating liquid. This paper aims to raise the efficiency of distribution transformers and preserve the environment by using a biodegradable insulating liquid instead of the conventional mineral insulating oil (MIO). This work examines the Egyptian case, where a real distribution network located in middle Egypt is selected as a pilot project. Study and analysis of the status que of the insulation system inside DTs are done with the aid of fault-tree analysis. The deficiency of the insulation system is confirmed by conducting an electronic survey of 100 expert participants. The most appropriate solution among three different alternatives is confirmed using the weighting and ranking method. The best choice suitable for the selected area is the substitution of MIO by synthetic ester (SE). The technical and environmental advantages achieved by the presented solution are discussed. The feasibility studies have proven that the solution is positively acceptable in all aspects. An execution plan is established for the application of proposed solution on the selected Egyptian distribution network.

Keywords: distribution transformers; mineral insulating oil; synthetic ester; natural ester; dry transformers; weighting and ranking; environment conservation; fault-tree; root-cause analysis; retrofilling

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1. Introduction

For more than a hundred years, mineral insulating oils (MIOs) have been used inside distribution transformers (DTs) to guarantee electrical insulation, suppress arcing in case of a fault and keep thermal stability. In order for the oil to fulfill these purposes, its appearance must remain clear, free from sediment or any suspended matters. New MIOs have to comply the international electrotechnical commission standard IEC 60296 especially in the requirement of lower viscosity, higher flash point and good resistance to oxidation [1,2]. Since its discovery by Eliu Thomson, MIOs were widely used due to availability, good dielectric properties and reasonable price. Nevertheless, MIOs are non-renewable fossil liquid with low biodegradable nature. Additionally, the periodic tests constantly affirmed the degradation of MIO properties by time even after following the maintenance guidance of IEC 60422 [3].

In general, distribution transformers are responsible for transferring energy between the different voltage levels in the utility network. Recently, this task has extended to include energy exchanges between the utility grid and the DC microgrids. However, the operation of oil-immersed transformers is limited by the thermal and electrical capabilities of the internal insulating liquids [4]. Moreover, the environmental hazards caused by MIO have reached an alarming level. Several incidents relating to transformer explosions have been reported worldwide [5]. Therefore, MIO no longer able to meet the variable operation and climatic conditions.

The disadvantages of MIO stimulated both scholars and manufactures to search for different insulation liquids inside DTs. Recently, some natural and synthetic liquids have been presented as substitutes for mineral oil. Silicone and ester fluids are examples of these substituting liquids [6–9].

Silicone is a synthetic liquid that was introduced as a substitute for MIO in special applications by the end of 1970s [6]. Unused silicone insulating fluid has to meet the requirements of IEC 60836 while used one is maintained according to IEC 60944 [10,11]. Silicone supersedes all insulating liquids in the oxidation stability. Silicone is distinguished from MIO in the higher flash point, the better thermal conductivity, and the lower dependency of viscosity to temperature variations. However, silicone shares MIO the serious problem of high moisture absorption, which deteriorates the electrical properties by time. One another imperfection in silicone is its non-biodegradability. These shortcomings in silicone, in addition to its high price, have intensified the search for better alternatives.

Ester fluids are other alternatives that were found by an English company in 1970s. The term ester comes from a chemical linkage formed from the reaction of chemical materials. Based on its raw material, ester fluids are classified into two main categories. The first category is the natural ester (NE), which is originally produced from natural plants such as soybeans and rapeseed [12–16]. Natural ester is firstly extracted in the form of a vegetable oil. The extracted oil is then treated to give the required properties. Unused NE fluids have to follow the requirements of IEC 62770 [17]. The IEC guidelines for the maintenance of used NEs are recently issued in IEC 62975 [18].

The second category of ester fluids is the synthetic ester (SE), which is chemically produced from the reaction of mixing specific acids with alcohol at high temperature, followed by treatment to meet the desired properties [19,20]. New SE fluids are produced according to IEC 61099 while the in-service ones are maintained in accordance to the guidance of IEC 61203 [21,22]. The technical properties of SE and NE as compared to those of other insulating liquids are listed in Table 1.

The fire safety classes in the first row of Table 1 follow the definition of IEC 61039 [23]. Each class has two characters code. The first character is a letter denotes the fire point. Letter “O” is referred to fire point less than or equal 300 °C and letter “K” is referred to fire point greater than 300 °C. The second character is a number denotes the low heat value (net calorific value). Number “1” is referred to net calorific value greater than or equal 42 MJ/kg, “2” is referred to net calorific value less than 42 MJ/kg down to 32 MJ/kg and “3” is referred to net calorific value less than 32 MJ/kg.

One additional solution is the replacement of the oil-immersing insulation system of transformers by the dry cooling technology [24,25]. Dry-type transformers are DTs that are cooled by either natural or forced air. The windings in a dry transformer are surrounded by a thick and rigid layer of cast/resin material. Such material cannot re-shaped and makes the transformer coils as a single mass. Dry transformers have the advantages and disadvantages that will be discussed in detail in Section 3.3.

Those different solutions left the distribution system operator (DSO) wondering which choice would be the best. The answer to this question is somewhat confusing given that each alternative has its advantages and disadvantages depending on operational, climatic and economic considerations [26,27].

This paper tries to help answering this question in a quantitative manner by the application of a multi-criteria decision making technique (MCDM) [28–30]. The weighting and ranking method is a direct MCDM technique in which a precise weight has been assigned to each selected criteria. As a first step, each criteria is carefully ranked according to the criteria importance and utility priorities. Weights are then assigned to each criteria in each alternative by an expert person in order to achieve the most appropriate decision.

Among the many types of MCDM techniques, the weighting and ranking method is chosen due to the simplicity and its applicability to this research scope.

Table 1. Properties of four different insulating fluids [6–8].

Technical Performance	Mineral Oil	Silicone Oil	Natural Ester	Synthetic Ester
Fire safety class	O1	K3	K2	K3
Fire point °C	170	>330	>350	>300
Flash point °C	160	>300	>315	>275
Biodegradable	✖	✖	✔	✔
Breakdown voltage kV	70	60	>75	>75
Moisture saturation (ppm @ 20 °C)	55	200	1100	2700
Oxidation ASTM D2112 (minutes)	300	450	<40	421
Dissipation factor %	0.005	0.01	0.009	0.001
Kinematic viscosity (mm^2/s @ 40 °C)	16	40	45	28
Density (kg/m^3 @ 20 °C)	895	1100	919	970
Pour point °C	<−50	<−60	<−31	<−56
Temperature performance	Poor	Good	Good	Excellent

A real district located in the middle of Egypt is highlighted as a practical application of the proposed solution. The process of checking and maintaining the insulation system inside DTs is analyzed. Furthermore, the existing state of the system is evaluated by conducting an electronic survey. Fault-tree analysis is performed to catch the root-causes that deteriorate the efficiency of insulation system as a preliminary step to make the wright decision. The authors aim in this research to raise the efficiency of transformers and preserve the environment in Egypt by selecting the most appropriate substitute to the existing insulation and cooling system in Egyptian distribution transformers. This coincides with the vision of the Egyptian Electricity Holding Company (EEHC) and the objectives of its subsidiaries.

The rest of the paper has been organized in five following sections. The existing situation of the insulation system inside the Egyptian DTs is examined in Section 2 focusing on the case-study region. Section 3 clarifies the workable alternatives to improve the insulation efficiency inside DTs. Differentiation between the alternatives using the weighting and ranking method is described in Section 4 to determine the most appropriate solution for the selected district. The execution plan as applied to the selected district is discussed in Section 5 focusing on the feasibility studies, execution stages and execution period. Eventually, Section 6 summarizes the main conclusions.

2. Examination of the Egyptian Case

The Egyptian distribution network extends for more than half a million kilometers to serve more than 36 million customers through about 197,000 distribution transformers of about 86.3 GVA total capacity. Middle Egypt Electricity Distribution Company (MEEDC) is one of nine distribution subsidiaries of the EEHC. As shown in Figure 1, MEEDC covers a part of Upper Egypt, known for its high summer temperatures [31]. MEEDC supplies electricity to 3.9 million customers through 26,100 transformers of about seven GVA installed capacity. All of the transformers owned to MEEDC are oil-immersed transformers filled by the conventional MIO.

Dir-Mawas, one of 56 districts belongs to MEEDC, was selected as the research area because a large number of its transformers are located near the very hot western desert. The total installed capacity in Dir-Mawas is 75.55 MVA distributed over 295 transformers. According to 2020 inventory, seven of Dir-Mawas transformers exceed the economic loading limits. The economic loading percentage of DTs is considered to range between 40 up to 80%. Loading below 40% is not desirable due to the low rate of investment return and the high effect of iron losses. Loading above 80% is not desirable also due to the danger of overheating in addition to the high effect of copper losses. During the last five years, MEEDC has added 20 new transformers to Dir-Mawas distribution network. Nevertheless, three transformers, rated 50, 100 and 160 kVA, were burned in Dir-Mawas during only the last summer.

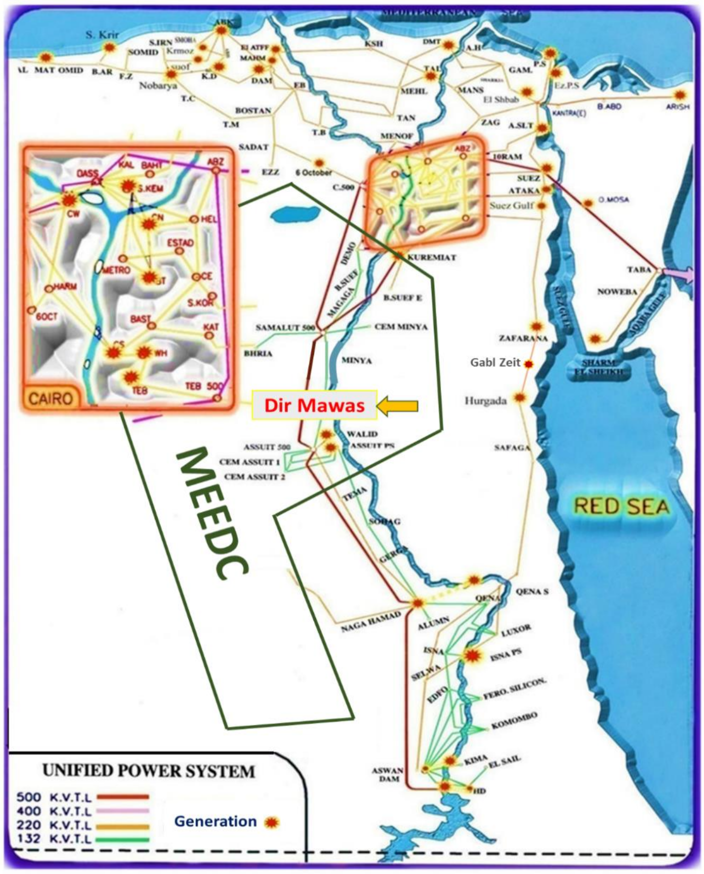

Figure 1. Location of the case study on the Egyptian electricity map.

To identify the existing state of DT cooling, a flow-chart of the periodic oil-inspection process in Egypt is drawn and given in Figure 2. The chart indicates all the process elements: process inputs, activities, outputs, owner, customer, components and feedback.

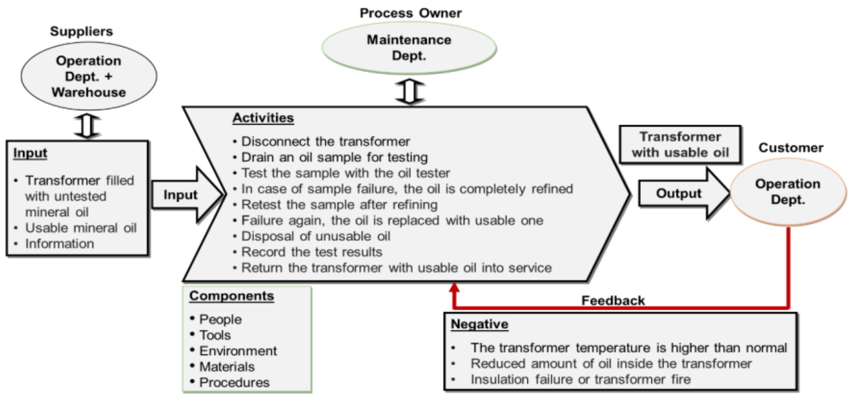

Figure 2. Process of inspecting the insulation system inside DT.

Studying the status-que clarifies that there is a problem, the symptoms of which are illustrated in Figure 3. These symptoms can be summarized in the following list:

- Increased number of burned transformers, especially in summer.
- The operating temperature of some transformers is higher than its rated values.
- Increased number of faulted transformers that leads to service interruption.

- Low level of oil inside some transformers.
- The degradation in oil properties by time, especially the breakdown voltage.
- Difficulty of drawing oil samples for testing.

Figure 3. Some symptoms that indicate the deficiency of insulation system inside DTs.

To confirm, an electronic survey is conducted to assess the cooling and insulation system of distribution transformers. A number of 100 experts from various parties and companies affiliated with the electricity sector in Egypt were responded to the survey. The results of the questionnaire confirm the existence of a deficiency in the existing cooling and insulation system of the Egyptian DT as shown in Figure 4.

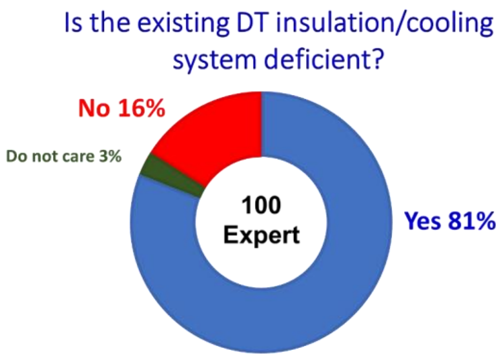

Figure 4. Results of the electronic survey.

Figure 5 illustrates graphically the relationship between all possible causes of the problem and their effects in a fault-and-effect tree [32]. From this fault-tree, a list of the possible causes can be created. The possible causes are then filtered using the root-cause analysis technique to identify the root-causes of the problem [33–35]. The resultant root-causes are:

- Winding insulation failure.
- Insulation paper damage.
- Low value of breakdown voltage of used MIO.
- High percentage of dissolved gases and non-preferred substances in MIO.
- Oil sediments.

- Low flash point of MIO.
- High moisture content in MIO.
- High loading of DT.

As is evident, most of the root-causes are related to MIO. Even root-causes that are not directly related to MIO, MIO causes them indirectly. Although moist is normally released during heat exchange with insulation paper, this moisture weakens the dielectric strength of MIO. As temperature rises, MIO as a hydrocarbon mixture reacts with oxygen to form black sediments. These sediments stick to the surface of transformer coils, creating heat isolators and reducing the surface of cooling area. Therefore, the next section of this paper discusses different alternatives to eliminate those causes.

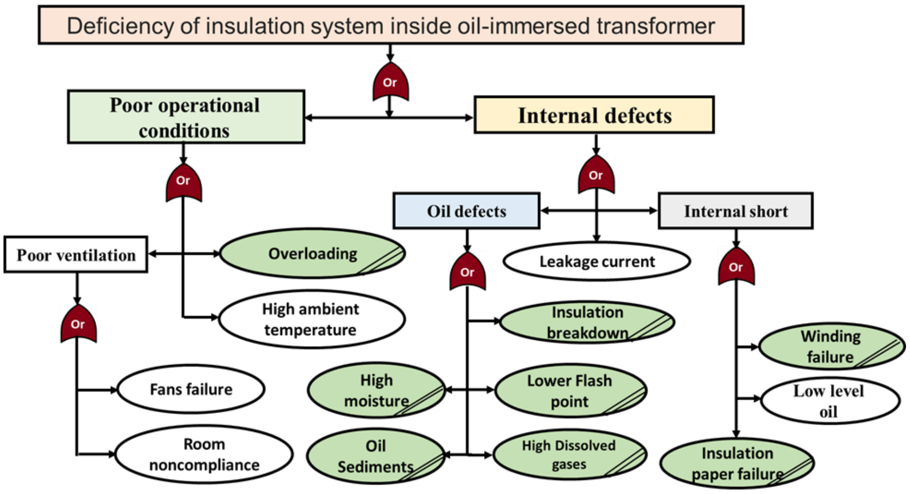

Figure 5. Fault-tree analysis of the deficiency of insulation system inside oil-immersed DTs.

3. Solution Alternatives

Focus in this section will be concentrated on three alternatives that contribute to solving the deficiency of the insulation and cooling system inside oil-immersed distribution transformers. These alternatives are ranging between the substitution of MIO by ester-based liquids and replacing the oil-immersed transformers by dry-type ones.

3.1. MIO Substitution by Ester

As compared to MIO, the use Ester fluids achieves the following benefits:

3.1.1. Suppress Transformers Burn

For any fire to occur, three elements must be combined: fuel, air, and temperature. No burn occurs if any of these elements are vanished. Thus, the presence of mineral oil, which is a petroleum derivative, facilitates transformers fire as the temperature rises. Ester fluids have a flash point exceeds 300 °C. This moves an ester-immersed transformer to the highest fire safety class according to the IEC 61039 standard [23]. Many tests have been conducted to confirm the superiority of fire diffusion characteristics in Ester over MIO [36].

3.1.2. Environment Conservation

According to environmental laws, used mineral oils are classified as hazardous wastes due to its low biodegradability. Therefore, it is forbidden to trade these oils without prior license. On the other hand, ester fluids are degradable materials according to the Organization for Economic Co-operation and Development (OECD). Following the guideline for chemicals testing OECD 301B, Figure 6 compares the biodegradation rate of different insulating fluids [37,38]. Figure 6 confirms that ester fluids, whether synthetic or natural, are superior to other insulating liquids in terms of preserving the environment.

3.1.3. Renewable Resources

MIO are generally produced by distilling the fossil crude oil that are gradually depleted. Therefore, MIO prices are subject to increase year by year. The need for renewable resources of insulating liquids that have a sustainable characteristic becomes urgent. Despite the fact that the Arab-Gulf countries are among the world's largest oil exporters, they have tended to replace MIO by ester in their transformers [39].

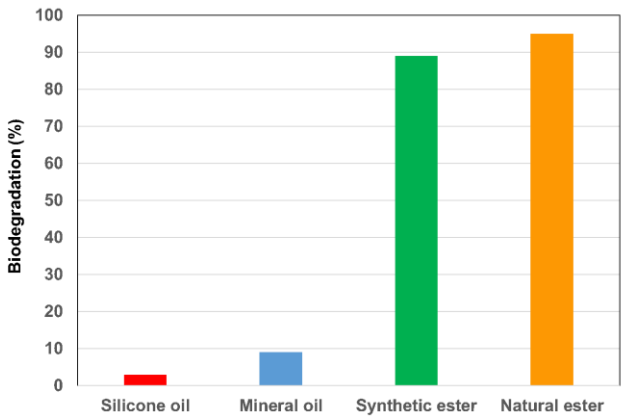

Figure 6. Biodegradation rate of different insulating fluids.

3.1.4. Low Maintenance

Due to its stability at higher temperatures and humidity levels, ester fluids are ideal solution for low maintenance applications. The use of ester achieves the following [26,27]:

- Keeps the breakdown voltage high even at high levels of moisture content. Regarding this point, Figure 7 verifies the superiority of ester fluids over other insulating liquids.
- Reduces the requirements of refining, which saves time, effort and money.

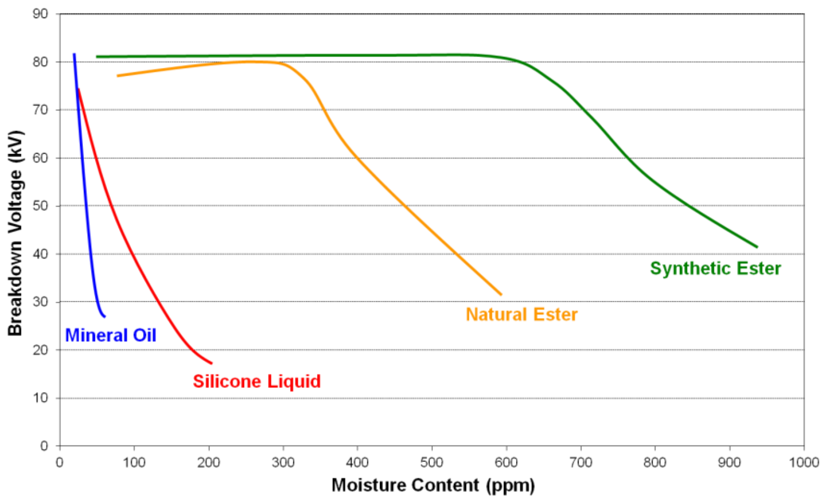

Figure 7. Effect of moisture content on breakdown voltage for different insulating fluids.

3.1.5. Small Size

Obviously, K-class cooled transformers can be designed for smaller dimensions than those of O-class cooled ones. For example, Figure 8 represents an ester-immersed DT of 2300 kVA rated power and 22/0.4 kV transformation ratio. This transformer is designed for KNAN cooling system. The length × width × height dimensions of this transformer are 233 cm × 77 cm × 167 cm respectively. The dimensions of a transformer of the same rate but MIO-immersed (ONAN cooling system) are 240 cm × 187 cm × 238 cm. i.e., the width of ester-immersed DTs can be reduced by up to 58.8% of the width of MIO-immersed ones. The height can also be reduced by up to 29.8%.

Figure 8. Relative small size 2300 kVA ester-immersed transformer with KNAN cooling system.

3.1.6. Long Lifetime

Reference [40] confirmed that NE fluids maintain its good condition that matches the requirements of new fluids after 7 years of continuous operation. Moreover, IEC 60076-14 [41] indicates that the use of ester insulating fluids extends the life of insulation paper inside DTs at different temperatures, as shown in Figure 9. This feature gives DTs the ability to withstand overloads up to 20% more than rated capacity.

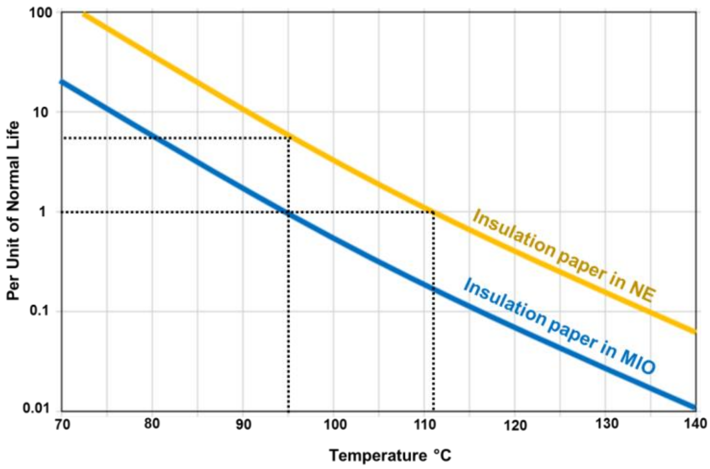

Figure 9. Relative ageing of insulation paper at different temperatures.

3.1.7. Miscibility

Miscibility is a property that determine the ability of an insulating liquid to be mixed with other equivalent liquids by any quantity without any changes affecting their efficiency or validity for insulation inside the electrical equipements. Both NE and SE are miscible with MIO in all proportions but not miscible with silicone fluids at all. Small amount of silicone cause foaming when mixing with ester fluids or MIOs.

3.2. Effect of Tank Design

Oil-immersed DTs are manufactured in either sealed tanks or free breathing tanks. Free breathing design is predominant in Egypt due to ease of maintenance and other economic considerations. Free breathing design allows the expansion and contraction of insulating oil through the conservator. The top level of oil inside the conservator is in direct contact with air. Although a desiccating device containing silica-gel crystals is used to keep the air inside conservator as dry as possible, this does not prevent the insulating liquid from being oxidized. As concluded from Table 1, this design is not appropriate for natural ester due to the high susceptibility of natural ester to oxidation [42]. Therefore, natural ester requires special fittings in non-sealed design to prevent oxidation and minimize air exposure, which increases the manufacturing cost. Despite the continuous efforts to improve the oxidation stability of natural ester by antioxidant additives [43], synthetic esters are best suited to retrofill both sealed and free breathing transformers.

3.3. Dry Cooling Technologies

Some features distinguish the dry-type transformers over the oil-immersed ones. Low maintenance requirements, the ability to be loaded at higher levels compared to MIO-immersed DTs and safely tap-changer switching are examples of these features. However, dry transformers in Egypt have remained limited to specific private-applications such as hospitals, factories, and hypermarkets. Dry-type transformers have not been popularly used due to the following reasons:

- Dry transformers are uneconomical for small power rates.
- The total area required to install dry transformer is relatively large due to the requirement of some extra accessories such as the enclosure and fans.
- Losses are relatively higher in dry transformers, especially at low loading conditions.
- The cost of the dry transformer is relatively higher.
- The windings in dry transformers are non-repairable.
- The noise level is relatively higher in dry transformers.
- Dry transformers are sensitive to polluted environment.

4. The Appropriate Solution

Throughout this section, three distinct alternatives are compared to distinguish the most appropriate one for the Egyptian case. As shown in Figure 10a, the three alternatives are identified as:

- Alternative (A): Substitution of MIO by SE.
- Alternative (B): Substitution of MIO by NE.
- Alternative (C): Replacement of oil-immersed transformers by dry-type ones.

The weighting and ranking method is chosen to differentiate between the alternatives. This method is based on arranging the alternatives according to given criteria. As indicated in Figure 10b, four criteria are selected to differentiate between the three alternatives. The four criteria are the cost, the quality, the applicability and the execution time. The quality criterion has assigned the highest priority, and then the criteria of cost, applicability and execution time are arranges respectively. The quality criterion includes not only the technical assessment of each alternative but also the environmental impacts such as fire suppression, biodegradability and renewability.

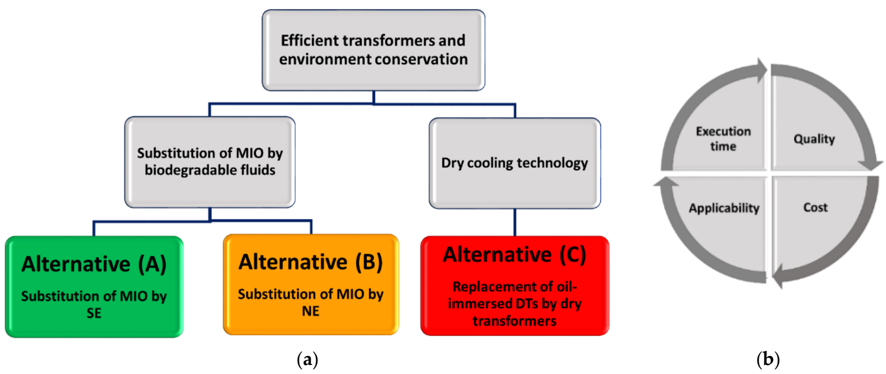

Figure 10. Solution alternatives and differentiation criteria: (**a**) the nominated three alternatives; (**b**) the four criteria for differentiation between alternatives.

Table 2 indicates the estimated weights and ranks of each criterion per each alternative as for the Egyptian case. Figure 11 represents the result of the weighting and ranking method indicating that alternative (A) is the high ranked alternative. Therefore, the most appropriate alternative for Dir-Mawas is the gradual substitution of MIO by SE.

Table 2. Application of weighting and ranking method.

Criteria (*)	Alternative (A)	Alternative (B)	Alternative (C)
Cost (R = 90)	High (W = 65)	Medium (W = 100)	Very high (W = 0)
Quality (R = 100)	Very high (W = 100)	Medium (W = 0)	High (W = 70)
Applicability (R = 80)	Medium (W = 100)	Difficult (W = 70)	Very difficult (W = 0)
Execution time (R = 70)	Long (W = 65)	Very long (W = 0)	Medium (W = 100)

(*) R = Rank, W = Weight.

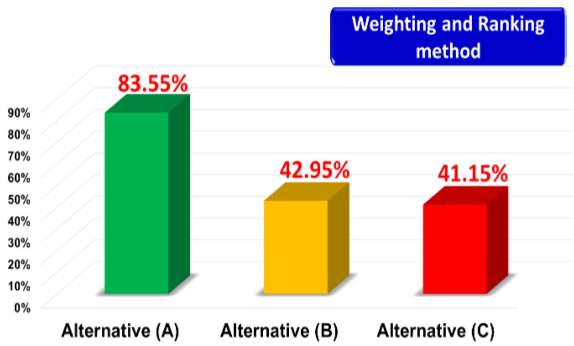

Figure 11. Result of the weighting and ranking method as applied to the solution alternatives.

5. Execution Plan

Ester price was expected to be higher than that of MIO, which affects the transformer cost [44]. However, the cost-to-benefit analysis may lead to change that belief as will be explained hereafter. As given in Figure 12, the execution plan can proceed in two phases: the first phase include the retrofill of existing highly loaded distribution transformers of less than five years lifetime. The second phase is the replacement of highly loaded old transformers by new SE-immersed ones of the same power ratings. As applied to Dir-Mawas, eleven DTs are included in the first phase and three DTs are included in the second phase.

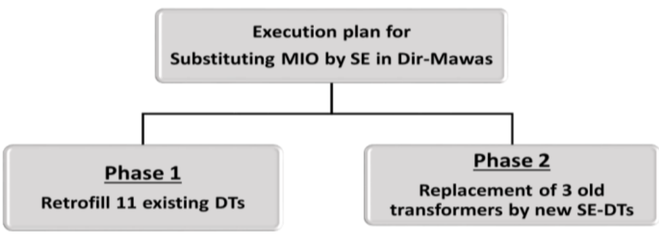

Figure 12. The execution plan for substituting MIO by SE in Dir-Mawas.

5.1. Feasibility Studies

Technical and operational conditions of Dir-Mawas transformers show that eleven DTs shall be included in the first phase while three DTs shall be included in the second one. The traditional solution for DTs of the first phase is to perform transformers replacement chain while the traditional solution for DTs of the second phase is to replace these MIO-immersed

DTs by other MIO-immersed ones of higher rates. The cost difference between the proposed solution and the existing solution was estimated for around 228,000 Egyptian pound (EGP) as detailed in Table 3. Cost calculations throughout this research are based on the price list given in Appendix A.

Table 3. Proposal cost compared to existing cost.

Item	Description	Quantity	Cost of Existing Procedures (EGP)	Cost of Proposed Solution (EGP)
1	Cost of training on retrofilling works	3 days	0	10,000
2	Cost of SE required for retrofilling the eleven DTs of phase 1	3967 kg	0	317,360
3	Old DTs replacement as per phase 2	3 DTs	406,883	307,205
	Total Cost		406,883	634,565

An economic feasibility study was performed on a MIO-immersed DT of 300 kVA with 85% loading percentage as a sample. As shown in Figure 13, the traditional solution is the replacement of this transformer by another MIO-immersed one of 500 kVA. This provides an additional capacity in the new transformer of 170 kVA for a cost rate of 382 EGP per each available kVA. The application of the proposed solution provides only substitution of the MIO by SE inside the existing transformers. This substitution increases the transformer efficiency and its ability to withstand up to 120% of its rated capacity of continuous operation without harmful effects. This provides an additional capacity of 105 kVA for a cost rate of only 75 EGP per each available kVA. This confirms that the proposed solution can achieve economic savings of up to 80%.

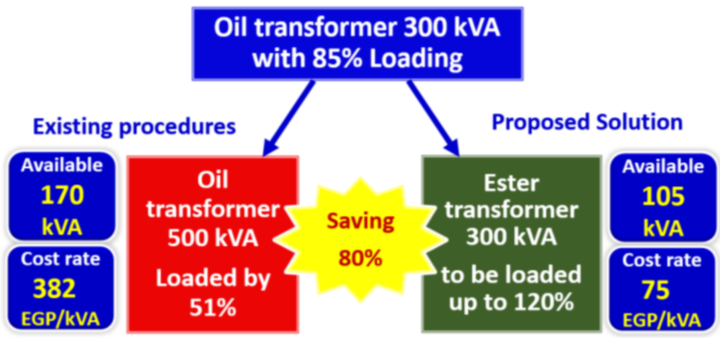

Figure 13. Economic feasibility for 300 kVA SE-immersed DT.

5.2. Execution Stages

The plan to apply the solution on Dir-Mawas is divided into five stages:

- Persuading stage: during which a series of meetings and seminars are held with stakeholders to highlight the importance and feasibility of the proposed solution.
- Planning stage: during which feasibility studies are confirmed, technical specifications are modified and funding sources are identified.
- Procedures stage: started with the official approval for bidding and followed by the technical and financial analysis of proposals, notification to proceed, and contracts signing.
- Actual execution stage: includes training, material supplying, retrofilling, installing the new SE-immersed DTs, and testing.
- The final stage is the follow-up during which periodic assessments of SE-immersed DTs are performed.

5.3. Execution Period

A project schedule for the execution plan including the project's phases and activities was established. With the aid of Microsoft Project software, the Gantt chart was plotted to relate activities with each other to study the possibility of reducing the overall implementation time. As illustrated in Figure 14, Gant chart determines the total execution time where the accumulated time of the project as applied to Dir-Mawas district is estimated as 213 working days. Although the retrofilling process does not take long, the longer time is for administrative and organizational procedures. The project lasts for approximately 290 calendar days considering vacations, waiting periods for decisions and waiting periods for performance monitoring.

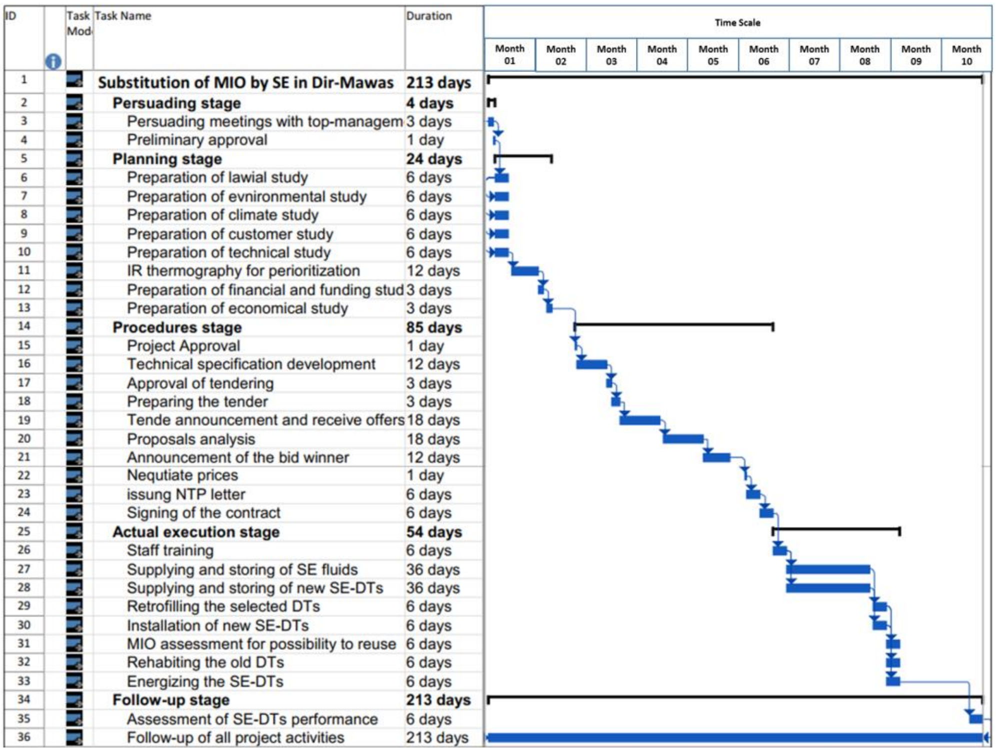

Figure 14. Gantt-chart for the project of substituting MIO by SE in Dir-Mawas.

6. Conclusions

This paper highlights the deficiency problem in the existing MIO-immersed DTs. Different tools are used to define the problem, examine its symptoms, and analyse its root-causes. Dir-Mawas (in the middle of Egypt) was selected as a research area. The researcher suggested three different alternatives to solve the detected problem. The first alternative was substituting MIO by synthetic ester (SE) liquids. The second one was substituting MIO by natural ester (NE) liquids. The third was replacing oil-immersed transformers by dry ones. The weighting and ranking method was used to differentiate between the three alternatives and select the most appropriate one. Four differentiation criteria were used: the cost, the quality, the applicability and the execution time. The most suitable solution for Dir-Mawas area was replacing MIO by SE liquids.

The presented solution achieved many advantages, including preventing the occurrence of any transformers fire, preserving the environment and maximizing the reliance on renewable materials. Furthermore, the replacement of MIO by SE increased the transformer life-time, reduced the need for maintenance and offered the possibility to design transformers with smaller sizes. The researchers had drawn up an execution plan to implement the proposed solution on the DTs of the selected area. The execution plan was divided into five stages: persuasive, planning, procedures, execution and follow-up. A Gantt chart was developed to monitor the timeline of each stage and estimate the overall project time. The overall project time as applied to Dir-Mawas was 213 working days including all administrative, organizational and retrofilling procedures. The feasibility studies had proven that the use of SE is positively acceptable in all aspects. Economically, using SE instead of MIO can reduce the cost per available kVA in DTs by up to 80%.

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Appendix A

List of the reference prices used in the evaluation and cost estimation throughout this research are given in this Appendix. Reference prices for 11/0.4 kV transformers of power ratings and different cooling types are given in Table A1. Table A2 represents a separate price list for different cooling liquids.

Table A1. Reference price list for 11/0.4 kV distribution transformers of different cooling liquids.

Item	MIO-DT Price (EGP)	SE-DT Price (EGP)	Dry-Type Price (EGP)
Transformer 200 kVA	93,180	95,340	106,780
Transformer 300 kVA	113,886	116,525	130,508
Transformer 500 kVA	179,111	183,262	205,254
Transformer 1000 kVA	244,337	251,213	280,814

Table A2. Reference price list for different cooling liquids.

Item	MIO Price (EGP)	NE Price (EGP)	SE Price (EGP)
Price of 1 kg	51	56	80

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