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Reliability Assessment of Distribution Power System When Considering Energy Storage Configuration Technique

MEHMET RIDA TUR, (Member, IEEE)
TBMYO Electrical and Energy Department, Batman University, 72500 Batman, Turkey
e-mail: mrida.tur@batman.edu.tr

ABSTRACT The main task of distribution systems is to provide acceptable reliability, economic and quality service of electrical power according to the demanded load value. To fulfill this task more accurately, the reliability performance of the distribution system can be performed and measured using a wide variety of indices, which are divided into energy indices and frequency/expectation indices. This study evaluates the reliability indices of a part of the distribution network selected as a model and deals with the selection of the most suitable feeder by connecting energy storage units to the busbars. Using IEEE Standard 1366 reliability indices, historical data from Prosperous Electricity Distribution Company (PEDC), which is used to evaluate reliability based on the 5-year past reliability assessment of the power system (RAPS), was selected. In addition, as an innovation in this application process, energy storage systems (ESS) have been evaluated according to four different network configurations (A-B-C-D) to increase RAPS and achieve more realistic results. Using DigSILENT, ESS-based configurations are designed, comparisons are made, and configuration B is the best result to increase system reliability and the 80E6 feeder is optimal. In addition, reliability changes achieved by network configuration have demonstrated the importance of optimal configuration planning to improve the uninterrupted and sustainable energy quality of the system based on storage technology.

INDEX TERMS Energy storage, Monte Carlo methods, power distribution faults, power system control, power system reliability.

I. INTRODUCTION

The main task of the electric power system is to provide consumers with affordable, quality and acceptable reliable and uninterrupted energy. The ability of the system to perform this self-expected task during the operating period is called reliability. Electric power system reliability analysis is carried out on three levels. Reliability analysis at the level that includes the production region is performed to determine whether the system can meet the total system load of the generated power. It is the evaluation of the system related to meeting the load need at the level of big load points covering the production and transmission regions. In this study, the level covering all three regions is generally considered only as of the distribution system reliability assessment due to the size of the system. The reliability assessment of the modeled configurations and appropriate indices for the actual load points are calculated. The feeder-based storage model will contribute to uninterrupted energy in the system. Also, the indices obtained at the level covering the production and transmission regions have been neglected because the effect of the indices is very low.

The concept of reliability in the power system (PS) is defined as the probability of supplying the requested load adequately in the planned time in the case of nominal operation [1], [2]. Reliability can be divided into two basic parts, which are defined as system capability and system security. The ESS is frequently used both in the face of developing energy demands and to facilitate the integration of renewable energy into distribution power grids [3]. The capacity of ESS must be enough concerning the demanded energy demand and safety, which dynamically responds to the failure of the PS. Unsustainable electrical energy services have been restructured and identified as various generation, distribution

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and transmission companies. In addition, the responsibility for maintaining the reliability of the entire PS is divided by a single electrical service by all relevant companies [4]. In order to ensure the stable operation of a system, a power balance must be ensured by smart control under all circumstances. Thus, the system operators are adjusted to accommodate changes in the net requirement of the power output of transmissible production sources.

An implicit or explicit numbering process or Monte Carlo methods (MCM) sampling is based on reliability analysis methods. However, recently, methods based on artificial intelligence, both as an alternative to MCM for the exploration process and with MCM have been examined. It will examine the conceptual basis of the overall RAPS process and investigate the role of artificial intelligence methods in this context [5]. Commonly used reliability indices, including System Average Downtime Indices (SAIDI), System Average Downtime Frequency Indices (SAIFI), Average Service Availability Indices (ASAI), Customer Average Downtime Indices (CAIDI), and Downtime Customer Cuts by Index (CIII), are used to measure network reliability [6]. It is generally used as an IEEE-RBTS reference system [7].

Using the statistical and reliability theory of distribution networks, reliability indices are carried out on energy sustainability. There are analytical technical studies for the safety assessment of the distribution network including the distributed generation. Depending on the breaker control regions and the feeder sections, a directed relationship graph is generated for an electrical distribution network to define the structure of the distribution network [8]–[11]. The quality of the network is of paramount importance because the failures experienced by customers are due to failures in the distribution system. The accuracy and quality of the results obtained in the applications have been improved with the proposed new model [12]. The increasing capacity of wind and solar energy in PSs has greatly changed the distribution of energy supply over time. Unlike thermal power plants and hydrogenation, power generation can change frequently because these renewable sources are relatively uncontrollable [13]–[15]. Research on the quality of the network has progressed in a few areas, including the definition of reliability, index types, algorithms and applications for evaluation and comparison models. As a result of this study, it has been concluded that power plants, transmission lines, distribution systems, and substations can be successfully applied to the design, planning and operational analysis processes. In addition, both the development of smart grids and the success and risk analysis of the energy system including renewable energy have been successful in recent years [16]–[21].

The reliability approach of a PS is analyzed by analytical calculations or simulation procedures, which are analytical approaches based on mathematical models, compares the status of the system to four different configurations to obtain appropriate numerical solutions of system reliability indices [22]. The outputs of analytical procedures integrated into the system are limited to average values and standard deviations, simulation simulations provide additional results in the form of probability distributions, and therefore the most suitable feeder is preferred for reliability assessment.

Presenting a technique for generating dependent data [23] and applied this to the reliability analysis for generation plants involving multiple wind farms, the effects on the capability (or reliability) of the production system are demonstrated [24]. There are three basic parameters used to measure the reliability, which are loss of load expectation (LOLE), loss of energy expectation (LOEE) and loss of load frequency (LOLF) [25]. It has also been seen that the demand for PSs to assess capacity is carried out considering the effects of the demand response. In addition, a composite reliability model is presented for demand response [26]. Some simulation results (IEEE 37 and IEEE 8500) demonstrate the accuracy of the proposed real-time simulation based on large-scale scenarios, such as a test feeder, which may be useful for applications involving network reconstruction, distributed production management, storage control, and cybersecurity assessment [27].

The Taylor series approach calculates the reliability of the performance function and evaluates the reliability of the performance functions in terms of possible design variables, one of the first-degree reliability methods, the reliability index approach [28]–[30]. In this study, the most reliable feeder configuration was determined by considering different designs. In order to prevent these situations, either the reliability indices should be taken into consideration in the PSs or the ESS amount in the PSs must be kept against sudden interruptions [31]. This amount of ESS is usually provided by the amount of capacity needed if the largest power plant is out of order. However, this is not always enough, for which socioeconomic parameters should be considered as the Value of Lost Load (VOLL) and the Energy Not Supplied (ENS).

To ensure economic stability, many distribution companies are managed with various processes [32]. In the unlikely event of energy supply, customers can reduce losses by anticipating and reducing the likelihood of downtime during the day ahead or the day ahead of the planning process to avoid power outages. This economic gain is achieved by keeping the ENS value at a minimum, which is achieved by using the required ESS in unexpected power cuts. Unexpected situations that reduce system reliability adversely affect system planning, which can lead to system failures, sudden load changes, and adverse environmental conditions. Energy sustainability is very important as it does not experience disruptions such as power outages and the planning is directly affecting both costs and system reliability. Thus, it is preferable to provide energy through the safe feeder and the non-secure feeders should be rehabilitated. After the interruptions, measures were taken regarding the measures related to the electricity-saving measure and in the context of this electricity supply-demand gap, solutions to the problems related to the demand response, especially in the rise of electricity, were developed [33], [34]. The model used as part of the

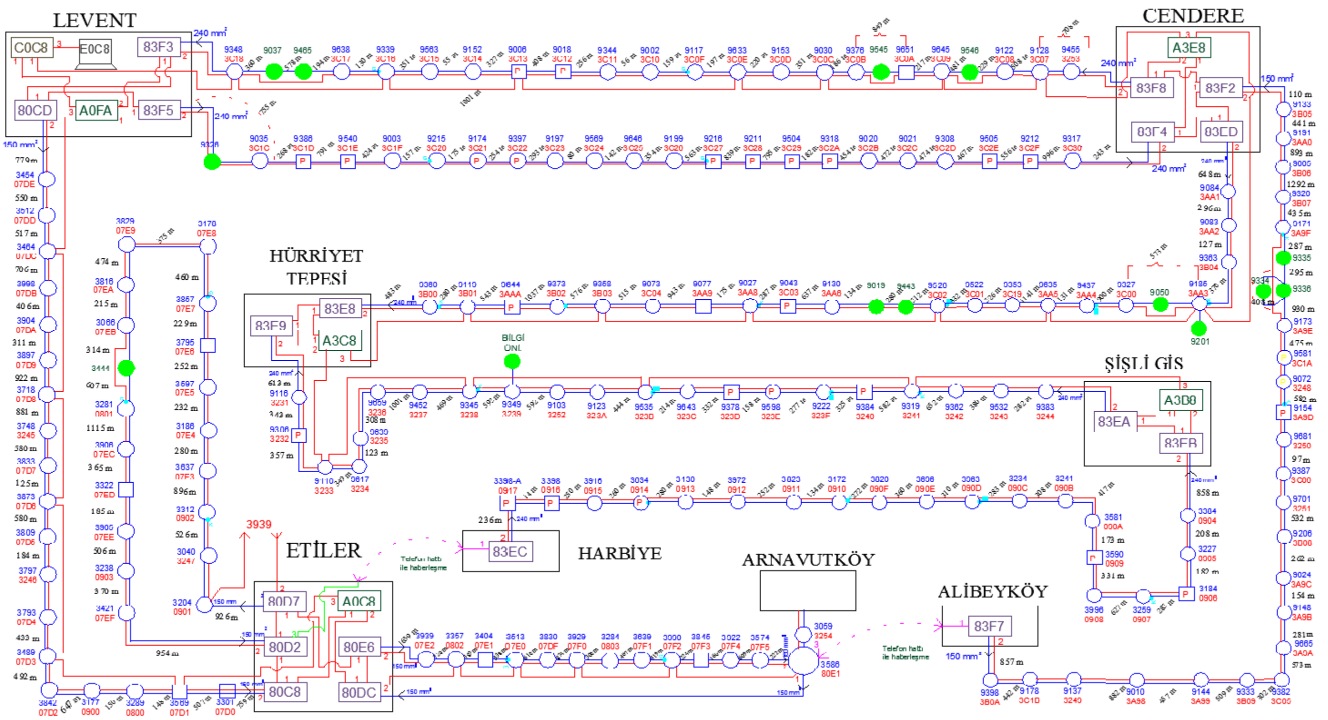

FIGURE 1. Part of the typical Istanbul distribution network configuration that provides the city load.

typical distribution network configuration that provides its actual load is shown in Figure 1.

VOLL is the money that consumers want to pay per kW to use continuous electrical energy, in other words not to be de-energized, which is a measure of the total capacity of power supply [35]. This value is determined by the preferences of consumers in the country where it is represented, and the power capacity received in the system is associated with the lost load [36]. A new framework for preparing switching operation procedures, considering the reliability of the power supply, has been made by determining a sequence of transition configurations obtained from the candidates for downtime planning [37]. There is a very important general situation for consumers, which is to ensure the best level of reliability, while the cost of using the electricity and the cost of the consumer is minimal [38].

In this study, it is aimed to obtain the most reliable design based on ESS by modeling based on cutter and feeder configuration. The configuration provided undertakes to provide uninterrupted energy, giving confidence to the consumer in providing more reliable energy. The novelty side of this method compared to other methods is that it is recommended to use an energy storage technology feeder based on switching design in the configuration. Thus, higher quality energy is provided in the distribution network by conducting reliability analysis with the MCM method. Costs or losses on the consumer side due to power outages are measured, for which there are some indices. It is mainly divided into energy indices and frequency/expectation indices, which are SAIDI, SAIFI, ASAI, CAIDI, and CIII. PEDC network consists of 13 feeders, which are in Etiler, Hurriyet Hill, Sisli Gis, Levent, Cendere and Alibeykoy regions. In this network, the number of Customers Interruptions to previous periods was 436014 in total. The total interruption Duration of the network with different interruption frequencies is 4694.58 hours. In addition, this model is designed in four different configurations with different switching points. Also, among the energy indices, the ENS is used to quantify the amount of MWh that is not supplied due to a reliability problem.

II. THE RELIABILITY INDICES OF POWER SYSTEMS

Network connection standards are very important for reliability, efficiency, and cost [39]. The evaluation of the reliability of distribution network systems is divided into two parts, which are future performance estimation and historical performance measurement [40]. In addition, there are two index groups to evaluate the reliability performance of distribution systems, which are the system index and the customer load point index [41]. The generally accepted reliability indices, IEEE, which is the Standard P1366 number, are defined as the Rules for the Distribution of Electrical Reliability Indexes [42].

A. SYSTEM AVERAGE INTERRUPTION FREQUENCY INDICES (SAIFI)

The SAIFI is defined as the average number of interruptions a customer has experienced during the year or during the working period, which is the total number of interrupted customers divided by the total number of customers served. This value calculates the average number of minutes that a customer stays uninterrupted. Where N_i is the number of customers and λ_i is the failure rate to load point i.

$$SAIFI = \frac{TotalNumberOfCustomerInterruption}{TotalNumberOfCustomersServed} = \frac{\sum \lambda_i N_i}{\sum N_i} \tag{1}$$

B. SYSTEM AVERAGE INTERRUPTION FREQUENCY INDICES (SAIFI)

The SAIDI is defined as the most used performance metric for a continuous downtime, which is normally used to measure downtime for the average customer during each period calculated monthly or yearly. However, it can also be calculated on a daily or other time and is designed to provide information about a customer's average pause time. It is commonly known as minutes of customer outages or customer hours. Where N_i is the number of customers and U_i is the annual outage time of load point i.

$$SAIDI = \frac{SumOfCustomerInterruptionDurations}{TotalNumberOfCustomersServed} = \frac{\sum U_i N_i}{\sum N_i} \tag{2}$$

C. CUSTOMER AVERAGE INTERRUPTION DURATION INDICES (CAIDI)

The CAIDI is calculated as the average time to restore the service during any interruption, which is calculated similarly to SAIDI. However, the share should correspond to the number of customers cut and the total number of auxiliary customers. Generally, refers to the average time required to restore. Where U_i is the annual outage time, Ni is the number of customers and λ_i is the failure rate of load point i.

$$CAIDI = \frac{SumOfCustomerInterruptionDuration}{TotalNumberOfCustomersInterruption} = \frac{\sum U_i N_i}{\sum \lambda_i N_i} \tag{3}$$

D. CUSTOMER AVERAGE INTERRUPTION FREQUENCY INDICES (CAIFI)

The CAIFI value is calculated by the calculation method of the SAIFI value, which is used to measure the average number of interruptions per customer that is interrupted per year. It is generally obtained by dividing the number of interruptions by the number of customers affected by the interruption.

$$CAIFI = \frac{TotalNumberOfCustomersInterrupted}{TotalNumberOfCustomersServed} = \frac{\sum N_0}{\sum N_i} \tag{4}$$

E. CUSTOMER INTERRUPTED PER INTERRUPTION INDICES (CIII)

The CIII is used to give the average number of customers interrupted during an interruption. The value of CIII can be considered as the equivalent of CAIFI.

$$CIII = \frac{TotalNumberOfCustomersDuring}{TotalNumberOfInterruptions} = \frac{\sum N_i}{\sum N_0} \tag{5}$$

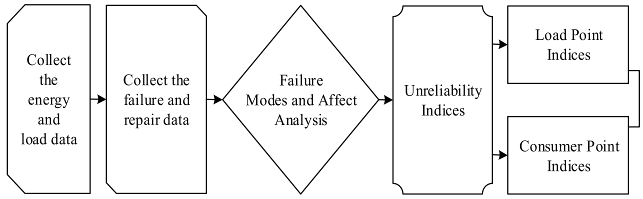

FIGURE 2. Steps of estimating reliability indices.

F. AVERAGE SYSTEM AVAILABILITY INDICES (ASAI)

The ASAI value is obtained as the ratio of the total number of customer hours that the service is available in each period to the total number of customer hours requested, which is also called the service reliability index. It is also calculated monthly (730 hours) or yearly (8760 hours) which can be calculated for each period.

$$ASAI = \frac{TotalNumberOfCustomersInterrupted}{TotalNumberOfInterruptions} = \frac{\sum N_i}{\sum N_0} \tag{6}$$

In order to obtain the reliability indices of the network model, which has been informed and analyzed, the steps shown below and shown in Figure 2 were performed.

- Fault data for all components integrated into the PS is provided.
- Switching and downtime data for all components integrated into the PS are provided.
- The average load and energy at all load points in the PS are calculated using the indexes directly using the data of the substations.
- Information is received about all connected consumers in the PS (e.g. number of customers).
- The length of the lines used in the PS is obtained.

After all these steps, the load point information for the feeders is estimated.

In this study, two cases are considered. In the first case, reliability indices are calculated at each feeder. The calculated indices are used to compare among the feeders concerning investment priority for rehabilitation.

III. THE MATERIAL AND METHOD OF SYSTEM

The listed steps are followed to evaluate the reliability of TEIAS down-load transformers and energy storage devices and distribution networks;

- To determine the malfunctions of the active components connected to the system,
- Choosing models with different configurations and assuming that a malfunction has occurred. Next, to simulate the operation of the required capacity for the protection power balance for the fault.
- Identify the zones created in the distribution network after the fault isolation: the flow of the fault, the inside of the fault and the downstream of the fault are shown in Figure 3.

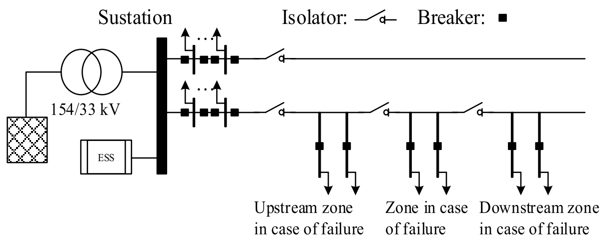

FIGURE 3. Zones in the distribution network after fault isolation within the network.

- The feed restoration for each area is then evaluated to calculate the failure rate and downtime, and the best configuration is achieved with switching differences.

A. CASE-1 GENERAL RELIABILITY ANALYSIS OF THE SYSTEM

In PSs, interconnected networks consist of a four-unit network model, and each unit network model is interconnected by four different interconnection configurations [43]. The total number of customers interrupted can be found by summing the customers at the downside of the interrupted feeders [44]. The total number of customers is 119842 for the distribution network under study. While reliability analysis on real distribution systems, basic load point indices and performance indices simulation method such as interruption numbers and durations of networks with simulation method, another feed line is 100% reliable in case of failure in open ring network [45]. The number of customers interrupted and interruption duration per each feeder is given in Table 1. The duration and number of discontinuities given are taken as the data of the last five years of the model. Thus, the use of past 5 years' data, which takes the total value for the historical reliability process, decreases the error rate and increases the accuracy rate.

For each feeder, these parameters were calculated separately, and the results were obtained. SAIDI, SAIFI, CAIDI, CIII, and ASAI indices are calculated for each feeder and shown in Table 2 [46].

In addition, the results of calculated indices are shown in Fig.3. It can be observed from Table 2 that Feeders 80E6, 83ED, 83F7, and 83F8 have the smallest SAIDI, 0.584, 4.71, 4.48, and 4.23 mines/interruption respectively. Therefore, the customers supplied from these feeders experience the least duration of sustained interruptions between all the feeders. On the other hand, the Feeders 80CD, 83F3, 83F2, and 83F5 have the highest SAIDI, 80.50, 51.72, 31.28, and 90.65 mines/interruption respectively, it can observe from Fig. 4. So that this feeder requires special attention and these feeders need to be paid more attention. Because the average interruption value is quite high, they are not reliable compared to other feeders.

TABLE 1. Summary of the collected data.

Area	Feeder's Code	Interrupt. Frequency	Customers Interrupted	Interruption Duration (min)
Etiler	80C8	7.00	19908.00	771.62
	80E6	1.00	685.00	102.17
Hurriyet	83E9	4.00	33038.00	218.28
Tepesi	83E8	1.00	8048.00	124.42
Sisli Gis	83EB	2.00	14287.00	288.10
Levent	83F3	8.00	54131.00	831.02
	83F5	7.00	189447.00	372.08
	80CD	2.00	12504.00	514.77
Cendere	83F8	1.00	8978.00	56.55
	83ED	2.00	14433.00	78.18
	83F4	3.00	41393.00	173.95
	83F2	6.00	25953.00	906.85
Alibeykoy	83F7	2.00	13209.00	256.60
TOTAL		46.00	436014.00	4694.58

TABLE 2. Feeders indices for the network under study.

Feeder's code	SAIDI	SAIFI	CAIDI	CIII	ASAI
80C8	19.15	0.166	115.30	2844	0.998429
80CD	80.50	0.104	771.58	6252	0.993397
80E6	0.584	0.005	102.17	685	0.999952
83E8	8.35	0.067	124.42	8048	0.999315
83E9	15.07	0.275	54.66	8259	0.998764
83EB	16.08	0.119	134.93	7143	0.998681
83ED	4.71	0.120	39.09	7216	0.999614
83F2	31.28	0.216	144.45	4325	0.997434
83F3	51.72	0.452	114.50	6766	0.995758
83F4	29.16	0.345	84.43	13797	0.997608
83F5	90.65	1.581	57.34	27063	0.992565
83F7	4.48	0.035	128.30	6604	0.999633
83F8	4.23	0.075	56.55	8978	0.999653

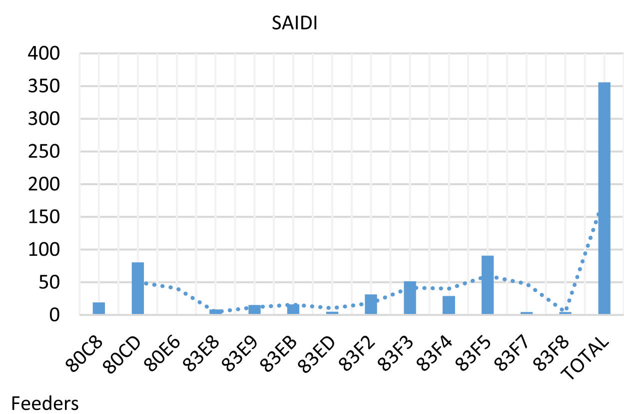

FIGURE 4. Reliability indices for the Feeders of network SAIDI.

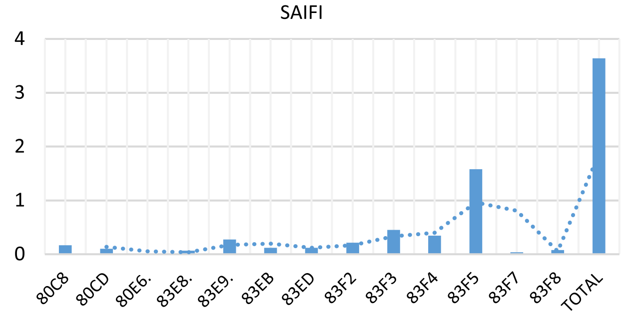

FIGURE 5. Reliability indices for the Feeders of network SAIFI.

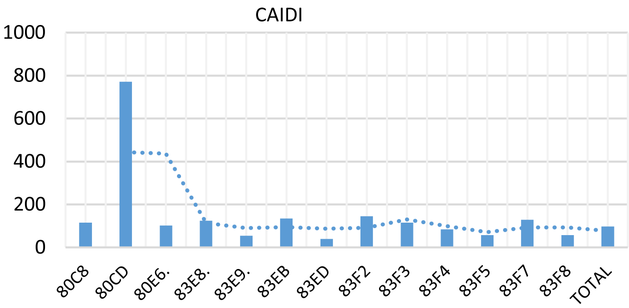

FIGURE 6. Reliability indices for the Feeders of network CAIDI.

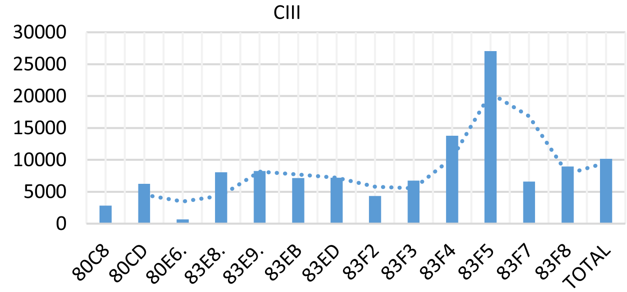

FIGURE 7. Reliability indices for the Feeders of CIII.

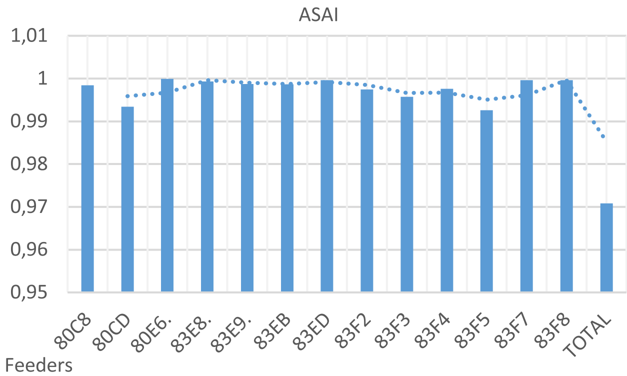

FIGURE 8. Reliability indices for the Feeders of network ASAI.

Similarly, Feeder 80E6, 83F7, 83E8 and 83F8 have the smallest SAIFI, 0.005, 0.035, 0.067 and 0.075 interruptions/customer respectively. Therefore, the customers supplied from this feeder experience the least occurrence of sustained interruptions between all the feeders. On the other hand, the Feeder 83F5, 83F3, 83F4 and 83E9 have the highest SAIFI, 1.581, 0.452, 0.345 and 0.275 interruptions/customer respectively, it can observe from Fig. 5. So that this feeder requires special attention.

Besides, Feeder 83ED, 83E9, 83F8 and 83F5 have the smallest CAIDI, 39.09, 54.66, 56.55 and 57.34 interruptions / customer respectively. Thus, the customers supplied from this feeder experiences the least occurrence of sustained interruptions between all the feeders. On the other hand, the Feeder 80CD, 83F2, 83EB, and 83E8 have the highest CAIDI, 771.58, 144.45, 134.93 and 124.42 interruptions /customer respectively, it can observe from Fig. 6. So that this feeder requires special attention.

Next, the Feeder 83F5, 83F4, 83F7, and 83E9 have the highest CIII, 27063.85, 13797.66, 8978 and 8259,5 interruptions /customer respectively, it can observe from Fig. 7. So that this feeder requires special attention.

Finally, in terms of reliability, it can observe from Fig. 8 that the 80E6 Feeder is the most reliable Feeder with ASAI equals to 0.999952; while 83F5 Feeder is the least reliable one with ASAI equals to 0.992565. These results can be examined in order of priority, to prioritize investments in the service organization (PEDC) in order to rehabilitate from the network. Based on this analysis, the worst feeder in terms of reliability can be rehabilitated first, for example, feeder 83F5 should be given priority for rehabilitation. In addition, the most reliable feeder can also be used, preferably with feeder 80E6.

B. CASE-2 THE RELIABILITY OF NETWORK FOR DIFFERENT STORAGE CONFIGURATIONS

In the second case, three configurations of network operation are considered. These configurations are compared with each other to system reliability. Dig SILENT Power factory is used to calculate the indices for all systems. The failure rate and maintenance data for the cable and transformer are shown in Table 3.

TABLE 3. Maintenance data for transformer.

Component	λ (Failure/Year)	r (hours)
Transformer -34.5/0.40 kV	0.025	3.0
Lines -34.5 kV	0.05	1.5

In these four case configurations selected for comparison, the feeder-dependent ESS is given in Figure 9, where different network models that can generate random switching points as A-B-C-D can be generated and cases are examined. Thus, clear conclusions will be drawn about which model the feeder-based design may be safer, which is designed for a more accurate analysis.

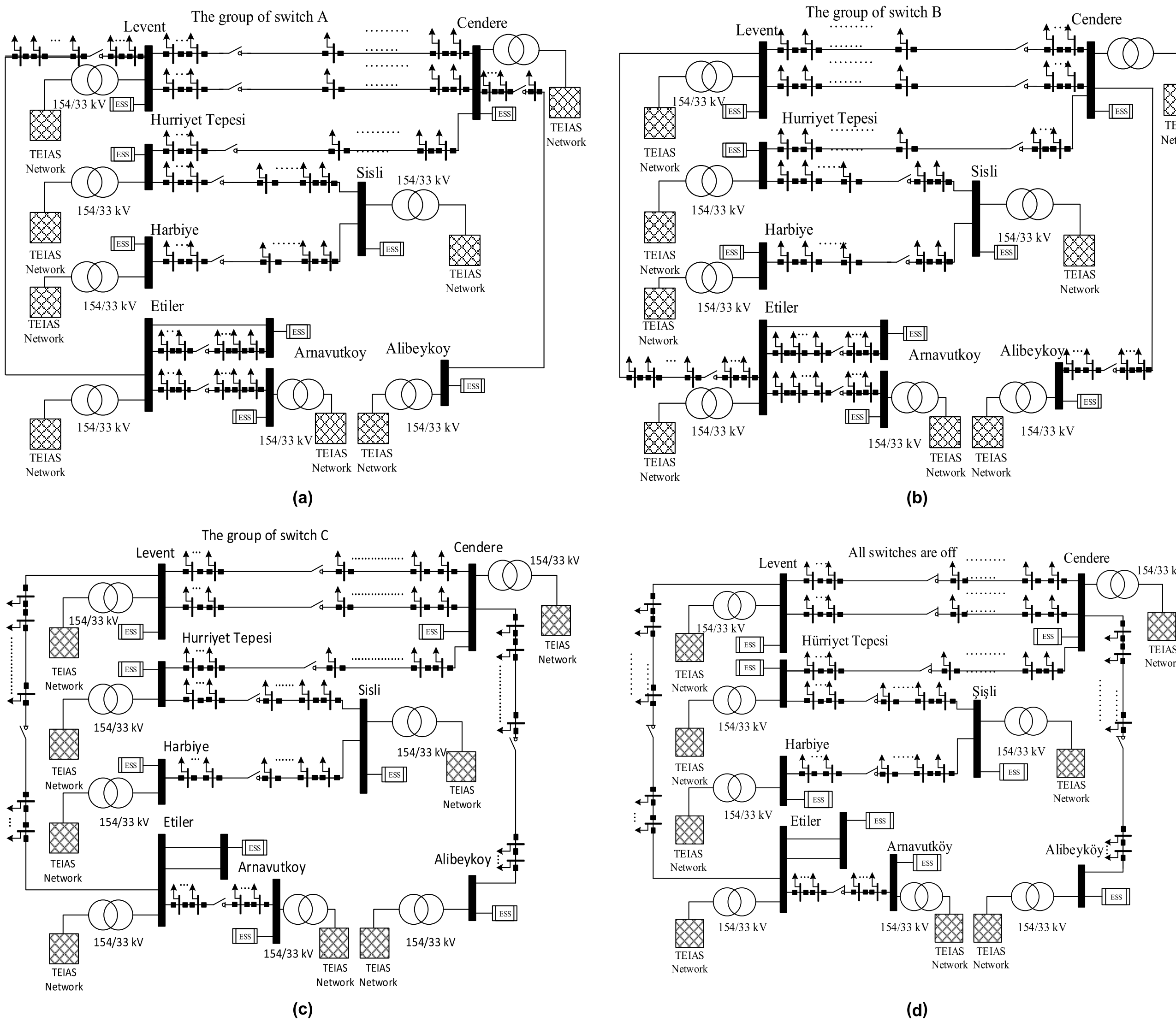

FIGURE 9. **Network configuration for different configuration (A-B-C-D).**

In this paper, most of the distribution networks associated with PEDC Company are modeled with Dig SILENT software. The RAPS is examined according to four configurations A, B, C and D, which are randomly selected for the position of the switches to be opened. The main concern of this study is to show the change in reliability according to the variation of network operation. According to the network model shown in Figure 2, the different switching states are used in four configurations A, B, C and D. Because reliability is evaluated according to the opening and closing status of switches with different points in the test system. In addition to the three locations in the form of a position close to the feeder, a midpoint, and a remote point, all switches are closed. The main purpose of making these configurations in different models is to form an interconnected structure by considering the points of the breakpoints before and after the bar and the distance from the busbar's point. Considering all these situations, the reliability analysis of the system was made and the data of the previous 5 years of the system were obtained. In order to make the system more reliable, it is aimed to select the most suitable feeder by controlling with a smart network configuration mechanism.

IV. ANALYSIS OF EVALUATION RESULTS

According to Table 4, the system in configuration B has the smallest SAIFI, 0.220627 downtime/customer with a better result than the A, C and D configurations. Therefore, the customers experience the least occurrence of sustained interruptions. On the other hand, the system in configuration D has the highest SAIFI, 0.326308 interruption /customer that means that the customers experience the highest occurrence of sustained interruptions. Similarly, the system in configuration B has the smallest SAIDI, 0.182-hour/customer.

The smart mechanism that makes these comparisons will work by considering the relevant parameters for the most appropriate configuration selection.

TABLE 4. Reliability indices for configurations A, B, C and D.

Configuration/Indices	A	B	C	D
SAIFI 1/Ca	0.237103	0.220627	0.25491	0.32630
SAIDI h/Ca	0.195	0.182	0.191	0.466
CAIDI h	0.821	0.824	0.749	1.428
ASAI	0.999977	0.999979	0.999978	0.999940
ENS MWh/a	58.16	54.293	55.341	153.13

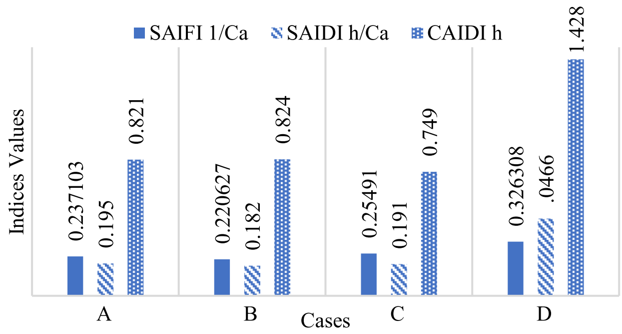

FIGURE 10. Network SAIFI, SAIDI and CAIDI indices for A, B, C and D configurations.

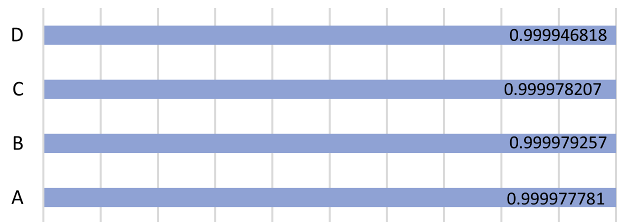

FIGURE 11. Reliability Indices (ASAI) for A, B, C and D Cases.

As a result of the comparison of the mechanism, customers have been chosen to ensure minimum downtime. However, contrary to the decision, the system in configuration D has the highest SAIDI of 0.466 hours/customer, as shown in Figure 10.

Whence, the customer average interruption the highest duration of sustained interruptions. In terms of reliability, the system in configuration C is the most reliable with CAIDI equals to 0.749 and in configuration D is the most unreliable with CAIDI equals to 0.1428 as shown in Fig. 6. It can be noticed that the system ENS increases with a decrease in its reliability. Therefore, the customers experience the highest duration of sustained interruptions. In terms of reliability, the system in configuration B is the most reliable with ASAI equals to 0.999979 and in configuration D is the most unreliable with ASAI equals to 0.999940 as shown in Fig. 11. It can be noticed that the system ENS increases with the decreasing in its reliability.

In this study, the mechanism that makes an intelligent evaluation creates the most economical and reliable configuration, and the results show how well the system works. While the value for the ENS in the selected B configuration

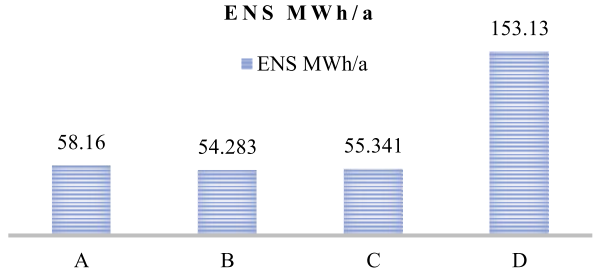

FIGURE 12. ENS for A, B, C and D cases.

is 58.16 MWh, the non-preferred has a maximum value equal to 153.13 MWh in the D configuration as given in Figure 12. Therefore, this clearly shows how reliability can be affected depending on the configuration of the network. Thus, the utility can select the optimum network configuration that maximizes overall reliability by performing the work.

According to the network configuration, SAIDI, SAIFI, ASAI, CAIDI, and CIII reliability change are the most reliable and reliable feeders for selecting the most appropriate configuration for increasing the reliability of the distribution network. The reliability indexes were designed with four different configurations including indexes. According to this situation, it has been suggested that investors use the most reliable feeder to operate the system by making investments to improve the feeder. This case limited only to show how the reliability could vary for variation of network configuration. As a result, future work can focus on determining the optimal configuration of the smart control mechanism using optimization algorithms, which is connected to the smart grid component and considers the demand situation.

In the results of the first case analysis, calculated indices, the feeders 80E6, 83ED, 83F7, and 83F8 had the smallest SAIDI, 0.584, 4.71, 4.48, and 4.23 mines/interruption respectively, which is the least uninterrupted interruption among all feeders. remains. Feeders 80CD, 83F3, 83F2, and 83F5 have the highest SAIDI, 80.50, 51.72, 31.28, and 90.65 mines / interruptions respectively, which is not reliable compared to other feeders as the average interrupt value is quite high. Feeders 80E6, 83F7, 83E8, and 83F8 have the smallest SAIFI, 0.005, 0.035, 0.067, and 0.075 interrupts/customers, respectively, which ensure that the supplied interruptions are minimal among all feeders. Feeder 83F5, 83F3, 83F4, and 83E9 have the highest SAIFI, 1.581, 0.452, 0.345, and 0.275 interruptions/customer respectively, which requires special attention. In addition, Feeders 83ED, 83E9, 83F8, and 83F5 have the smallest CAIDI, 39.09, 54.66, 56.55, and 57.34 interruptions/customers, respectively, which are the customers supplied from this feeder, with the least continuous interruptions across all feeders experienced. Feeders 80CD, 83F2, 83EB, and 83E8 have the highest CAIDI, 771.58, 144.45, 134.93, and 124.42 interruptions/customer, respectively, which needs attention. Finally, in terms of reliability, the 80E6 feeder is the most reliable Feeder with ASAI value 0.999952; The 83F5 Feeder equals 0.992565, which is the least reliable with ASAI.

The second Case analysis should first give priority to the 83F5 feeder for the worst nutritional rehabilitation in terms of reliability, and the most reliable feeder can preferably be used with the 80E6 feeder. The smallest SAIFI, which outperforms the A, C and D configurations, is the B configuration with 0.220627 interruptions/customer. The system in D configuration has the highest SAIFI value, 0.326308 interrupt/customer, and the highest 0.466 hours/customer SAIDI value, which is the longest downtime of the customer average interruption. The system in configuration C is the most reliable, which equals CAIDI 0.749, and in configuration D, the CAIDI is the most reliable system that equals 0.11288. The system in configuration B is the most reliable where ASAI is equal to 0.999979, and in configuration D, it is the most reliable where ASAI is equal to 0.999940. Although the ENS value in the selected B configuration is 58.16 MWh, the undesirable has a maximum value in configuration D equal to 153.13 MWh.

V. CONCLUSION

The results obtained seem to be extremely useful in terms of reference to the distribution system compared to other techniques used in the past RAPS. It is also an important tool in the planning, design and maintenance programming of PSs. In many utilities, past RAPS is an important approach to support ESS to identify weak parts of the network, then increase the reliability of these parts to achieve the best performance of the system. The importance of historical evaluation stems mainly from the fact that it is based on real data collected periodically by energy services.

In this article, past RAPS has been made for some of the PEDC related distribution network based on five years of real data. Results from the past RAPS of the PEDC section reviewed show that the 80E6 feeder is the most reliable, and the acne 83F5 feeder is vulnerable. The intelligent control mechanism to be used in the selection of the appropriate feeder is integrated into the system, taking into account reliability indices, and selects the most suitable configuration for the customer who will use uninterrupted energy with ESS. In summary, the historical method for RAPS is a powerful tool to identify weaknesses in the network and then makes smart decisions about the relevant remedial actions required to achieve certain levels of service reliability. In addition, one of the suggested solution actions is to change the network configuration through an intelligent configuration to increase the overall reliability of the system. The system in the B configuration has the smallest SAIFI, which gives better results than the A, C and D configurations, has 0.220627 interruptions/customers, which is the least continuous interruption. The system in configuration D has the highest SAIFI value and is 0.326308 interrupts /customers, which means that the customers have the highest continuous interruptions. Similarly, the system in B configuration has the smallest SAIDI, which is 0.182 hours/customer. As a result, four configurations based on ESS have been studied using DigSILENT, and configuration B is provided with a smart mechanism where it is best to increase system reliability and where the 80E6 feeder is optimal.

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MEHMET RIDA TUR (Member, IEEE) received the B.S. degree in electrical engineering from Marmara University, İstanbul, Turkey, in 2005, the M.Eng. degree electric and electronic engineering from the Institute of Science, Firat University, Turkey, in 2008, and the Ph.D. degree in 2018. He held a senior position with the Technical Programs of Mardin Artuklu University, Turkey, from 2010 to 2019. From 2010 to 2020, he held various positions at the Department of Electrical and Energy, Artuklu University and Batman University, Turkey. He is a coauthor of Electrical Energy in Turkey (Seta, 2017). Because of his interest in applying economic analysis and quality methods in power systems, he worked on many different aspects of his career in power engineering. He has been appointed to the Electric and Energy Department, Batman University, since 2019, where he is currently working as an Assistant Professor and the Head of the Department. The focus of his career has been on utility distribution systems. His main interests are protection-reliability, power systems quality, power systems economy, renewable energy systems, and smart grid. He is a member of the committee of the International Conference on Renewable Energy Research and Applications of the IEEE.