



3. Multicriteria Analysis for Quality and Reliability in Electrical Systems

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3.1 Introduction

Electrical Power Systems (EPS) generate, transmit and distribute electrical energy in strict operating ranges. To successfully fulfill these operational phases of the EPS, efficiency, safety, quality, and reliability standards must be established. Each of these standards is associated with variables that have to function within regulated limits. Various authors have proposed many methodologies to optimize these variables to work correctly within the established boundaries. However, most electrical variables present a relationship that can cause unwanted conflicts of interest. It is why more optimization methodologies have recently been proposed that involve the joint analysis of multiple variables (criteria) (1).

The Efficiency and Power Quality areas are closely related because most of the proposed improvement actions are associated with reducing the current flowing through the lines and reducing the line impedance's ohmic values. Regarding reliability, the proposed improvement actions are intended to reduce the number of failures per year and the restoration times of electrical service (2).

The multicriteria method proposes a robust and novel solution to problems with multiple interrelated objectives (decision criteria). In most engineering problems, mono-objective solutions affect other variables of the problem that have yet to be considered, resulting in a conflict that is often not visible if a multi-objective analysis is not carried out. The multicriteria method has application in decision-making about solutions that can be considered efficient individually. Still, it needs a joint study focused on a more authentic problem perspective (3).

Historically, the main improvement proposal to increase the efficiency and quality of electrical power systems has been reactive power compensation through optimal location and sizing of compensators. However, reactive power compensation at any voltage level affects multiple variables, which is why the impact caused by reactive compensation on each variable must be carefully analyzed. The main variables that must be studied in reactive power compensation problems are voltage profile, power losses, power factor, and voltage total harmonic distortion (1). The optimal operation of reactive power flows in electrical power systems has become a challenging problem due to the complexity of the new scenarios that present the penetration of renewable energies and energy storage. Added to this are non-linear loads, and unbalanced loads, making current circuits require new methodologies that consider the reality of the problem. Currently, the proposed compensation is dynamic, based on power electronics, and with an automated response that causes a high injection of harmonics into the network. For these reasons, it is necessary to consider all the requirements to determine the optimal location and sizing of reactive power-compensating devices at the lowest possible cost. For this, many heuristic and metaheuristic methods have been proposed that perform a search (exploration) on the study EPS presenting multiple iterations with compensation scenarios. But, this must be done with a new multi-objective consideration that allows delimiting the conflict between variables, seeking the solution that best responds to the global interest of all the decision criteria (1).

The evaluation of reliability in electrical power systems is also analyzed from multiple indicators that respond as decision criteria in the proposed improvement actions. Electrical failures harm the consumer in two different ways; the user is affected by the frequency of electrical service interruptions and the duration of the repair of these interruptions. Electric power distribution companies aim to minimize failures' frequency and duration (4). Achieving this demands significant investments that the electric power distributors must assume to guarantee the desired reliability indicators. These indicators for level 3 of Reliability in electric power systems (distribution level) are known as Average Energy Not Supplied (AENS), System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), and Customer Average Interruption Duration Index (CAIDI)

(5), (6). Measures to reduce failure rates and interruption repair times require considerable investment in human, material, and technical resources for repair and preventive and corrective maintenance (7). Different authors have established optimization methods that seek solutions for the sectioning location and automatic reconnection configuration. And these two improvement actions also produce different results in each reliability indicator. In the case of circuit reconfiguration, it also affects power flows with its quality and efficiency variables (8). The multicriteria decision methodology will allow a general optimal solution for the optimal location of the sectioning and the optimal reconnection problem. Most of the proposed methodological solutions respond to unilateral objectives of user satisfaction. Still, often the economic indicators of interest to the electricity distribution company are not considered in this analysis. For this reason, the joint analysis of all the objectives involved in this solution is vital. For this purpose, the multicriteria decision method appears as a multi-objective optimization alternative that also allows the establishment of weights on the decision criteria, an issue that provides greater flexibility for this study.

In this chapter, the multicriteria decision methodology will be presented as an alternative to solving engineering problems that require an optimal solution. The multicriteria method allows for solving optimization problems that depend on multiple variables considering the conflict that may exist between them (1), (6). Multicriteria, multi-objective optimization, or multicriteria decision-making methods solve optimization problems involving multiple conflicting objectives or criteria. In such issues, there may not be a single solution that optimizes all requirements simultaneously. Instead, there may be a set of keys, each performing differently concerning the different criteria. Multicriteria methods can help identify and evaluate this set of solutions, allowing decision-makers to choose the best balance of the conflicting criteria. Some standard multicriteria methods include the weighted sum method, the analytical hierarchy process, and the goal programming method. The multicriteria decision proposal will be applied to solve problems of Reliability and Quality of Electric power. For these studies, power flow calculations and stochastic analysis will be performed. The method's effectiveness is demonstrated in the analyzed issues, highlighting the conflicts with single-objective research. The graphic abstract of this investigation is shown in figure 3.1.

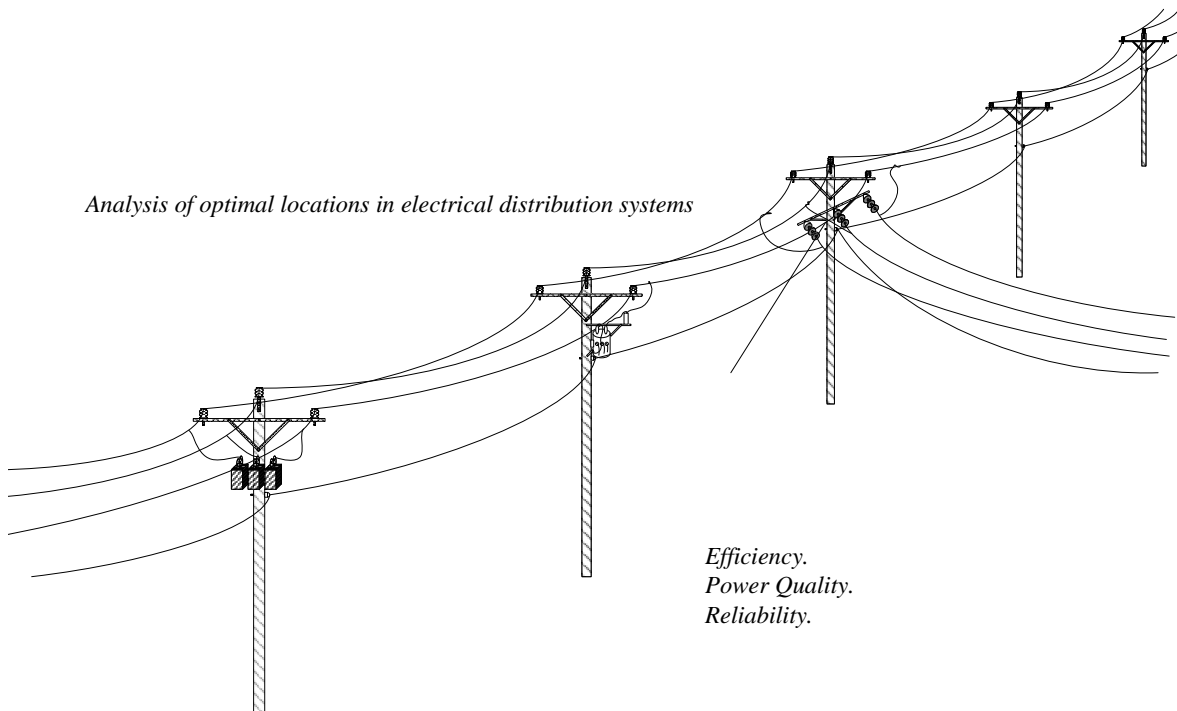


Figure 3.1: Graphical abstract of the research.

3.2 Related Works

Multicriteria decision-making (MCDM) involves evaluating and selecting alternatives based on multiple criteria or objectives, particularly relevant in electrical systems where various factors must be considered for optimal decision-making. Here's an overview of the key themes and research areas related to multicriteria decision-making in electrical systems:

Renewable Energy Integration: With the increasing penetration of renewable energy sources in power systems, researchers have focused on using multicriteria decision-making approaches to evaluate and select appropriate integration strategies. It includes the selection of optimal locations for renewable energy installations, determining suitable technologies for specific applications, and the assessment of different renewable energy scenarios.

Power System Planning and Operation: MCDM techniques have been applied to support decision-making in power system planning and operation. It evaluates alternatives for system expansion, optimal generation and transmission planning, network reconfiguration, demand response programs, and power quality improvement. Then, to make informed decisions, the goal is to consider multiple criteria

such as cost, reliability, environmental impact, and social aspects.

Smart Grid Applications: Multicriteria decision-making methods have been employed in the context of smart grids to address challenges related to advanced metering infrastructure, energy management systems, demand-side management, and grid modernization. MCDM techniques help select optimal energy efficiency solutions, demand response strategies, distributed generation integration, and load balancing.

Power Quality Assessment: MCDM approaches have been utilized to evaluate power quality issues and select appropriate mitigation strategies. The selection process considers criteria such as effectiveness, cost, and compatibility with the existing electrical system. It includes the assessment of voltage sag and swell compensation devices, harmonic filtering techniques, and reactive power compensation methods.

Fault Diagnosis and Condition Monitoring: Multicriteria decision-making methods have been applied in electrical system fault diagnosis and condition monitoring. These techniques help evaluate diagnostic options and select the most suitable method for fault detection, localization, and classification. The criteria for decision-making include accuracy, computational complexity, reliability, and cost.

Electric Vehicle (EV) Charging Infrastructure: With the rise of electric vehicles, MCDM techniques have been employed to determine optimal locations for EV charging stations, select charging technologies, and design charging infrastructure. The evaluation criteria include coverage, accessibility, charging speed, cost, and environmental impact.

These methods aim to provide a systematic and structured approach to evaluate and rank different alternatives or solutions based on their performance across multiple criteria.

Several multicriteria methods have been applied in the context of electrical power systems. Some of the commonly used methods include:

Analytic Hierarchy Process (AHP): AHP is a widely adopted multicriteria decision-making method that decomposes complex problems into a hierarchical structure and allows decision-makers to compare criteria and alternatives based on pairwise comparisons.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS): TOPSIS is a method that determines the best alternative by calculating the shortest distance to the positive ideal solution and the farthest distance to the negative perfect solution in a multidimensional space.

ELECTRE (Elimination Et Choix Traduisant la REalité): ELECTRE is a family of methods that assesses the performance of alternatives by comparing them to predefined criteria profiles. It uses pairwise comparisons and assigning concordance and

discordance indices to rank options.

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation): PROMETHEE is a multicriteria outranking method that compares alternatives based on predefined criteria. It uses pairwise comparisons and assigns preference indices to determine the overall ranking.

Fuzzy Sets Theory: Fuzzy sets theory is often employed to handle imprecise or uncertain data in multicriteria decision-making. It allows for a more flexible representation of preferences and can take subjective judgments.

These are just a few examples of multicriteria methods applied to electrical power systems problem-solving. Researchers have explored and developed various variations and combinations of these methods to address different decision-making scenarios within the field.

The multicriteria decision technique offers several advantages over other optimization methods for decision-making in complex problems. Here are some key benefits:

Consideration of Multiple Criteria: One of the primary advantages of multicriteria decision techniques is their ability to handle multiple criteria simultaneously. Traditional optimization methods focus on a single objective, neglecting other important factors. In contrast, multicriteria decision techniques allow decision-makers to consider and weigh multiple criteria explicitly, capturing the complexity of real-world problems more comprehensively.

Trade-off Analysis: Multicriteria decision techniques facilitate trade-off analysis between different criteria. They provide a systematic framework to evaluate the performance of alternatives across multiple measures and assess the trade-offs between them. It enables decision-makers to explore different scenarios and make informed decisions that balance conflicting objectives.

Subjectivity and Stakeholder Involvement: Multicriteria decision techniques accommodate subjective preferences and incorporate stakeholder involvement in decision-making. These methods allow decision-makers to express their preferences and priorities for different criteria, ensuring that the final decision aligns with their values. Stakeholders can participate in evaluating and weighing criteria, enhancing transparency, and increasing acceptance of the final decision.

Flexibility and Adaptability: Multicriteria decision techniques offer flexibility in adapting to different problem contexts. They can handle various criteria, whether quantitative or qualitative, objective or subjective. These methods can also incorporate uncertainty and sensitivity analysis, enabling decision-makers to assess the robustness of their decisions under varying conditions.

Transparency and Communication: Multicriteria decision techniques provide a transparent and structured decision-making process. They offer clear method-

ologies for evaluating alternatives, weighting criteria, and generating rankings or preferences. This transparency enhances communication among decision-makers and stakeholders, fostering a shared understanding of the decision-making rationale and promoting consensus-building.

Holistic Decision-Making: Multicriteria decision techniques promote a holistic approach to decision-making. By considering multiple criteria, these methods consider various aspects and impacts of the decision. It leads to more comprehensive and well-rounded solutions that address the complexities and interdependencies of real-world problems.

While multicriteria decision techniques have these advantages, it's important to note that the choice of optimization method depends on the specific problem and context. Some optimization methods, such as mathematical programming or evolutionary algorithms, may be more suitable for particular optimization problems, especially those with well-defined mathematical formulations and single objectives. It is crucial to assess the characteristics of the problem and select the most appropriate method accordingly.

3.3 Problem Formulation and Methodology

Various methodologies and approaches can be employed when optimizing electrical networks using multicriteria decision-making. Here is a general outline of a solution methodology that incorporates multicriteria decision optimization for electrical networks:

Problem Formulation: Clearly define the objectives and constraints of the optimization problem. Identify the criteria that need to be considered for decision-making in electrical networks. These criteria may include cost, reliability, voltage stability, power quality, environmental impact, and system efficiency.

Model Development: Develop a mathematical model representing the electrical network and incorporating the identified criteria. This model should consider the network topology, power flow equations, and other relevant constraints. The model should also include the decision variables that can be optimized, such as generation and load dispatch, capacitor placement, and network reconfiguration.

Objective Functions: Define objective functions that quantify the performance of the electrical network concerning the identified criteria. Each criterion may have its objective function. These objective functions should reflect the desired trade-offs between the measures.

Data Collection: Gather data on the electrical network, including load profiles, generation capacities, equipment characteristics, and cost information. Ensure that the data is accurate and up-to-date to achieve reliable optimization results.

Multicriteria Decision-Making: Apply appropriate multicriteria decision-making methods to evaluate and rank different optimization alternatives. Commonly used methods include Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), ELECTRE, and PROMETHEE. These methods help to weigh the criteria, assess the performance of each alternative, and determine the optimal solution based on the decision-makers preferences.

Optimization Algorithm: Utilize optimization algorithms to find the optimal solution that satisfies the defined objectives and constraints. Different algorithms can be used depending on the complexity of the problem, such as linear programming, mixed-integer programming, or evolutionary algorithms like genetic algorithms or particle swarm optimization.

Sensitivity Analysis: Perform sensitivity analysis to examine the impact of parameter variations and uncertainties on the optimization results. This analysis helps to assess the robustness and stability of the obtained solutions.

Validation and Implementation: Validate the optimized solutions through simulations and compare the results with existing network configurations or historical data. Once validated, the answers can be implemented in the electrical network, considering any practical limitations or operational considerations.

It is important to note that the specific methodologies and tools used for multicriteria decision optimization in electrical networks may vary depending on the scope and complexity of the problem. Researchers and practitioners often tailor the method to suit their needs and requirements.

The multicriteria decision methodology is proposed for this study with the following specifications. The solution to optimization problems using the multicriteria decision technique consists of finding the best solution vector (analysis scenario) within several suitable options (whole scenarios). This vector must be determined by decision criteria established in the objective vectors. The results of each criterion for each analysis scenario can be normalized using statistical normalization techniques. In this investigation, the normalization by ranges, also known as the method of the minimum and maximum values (MM), is shown in 3.1.

$$XiNorm = \frac{Xi - Xmin}{Xmax - Xmin} \quad (3.1)$$

The CRITIC method is a problem-solving used in decision analysis and decision-making. CRITIC stands for Criteria, Ratings, and Importance. It provides a structured approach to evaluating alternatives based on multiple criteria. This method determines the relative importance or weight of each criterion. Not all criteria are equally important; this step helps you prioritize them. Assign weights to each criterion based on your judgment or through a more systematic approach. The CRITIC

method helps decision-makers organize their thinking, consider multiple criteria, and make more informed and structured decisions. It provides a systematic framework for evaluating alternatives based on performance across various dimensions or criteria (3). Once the normalized decision matrix is available, the weightings can be established using the equation 3.2.

$$W_i = S_i \sum_{j=1}^n (1 - r_{ij}) \quad (3.2)$$

Where:

W_i is the weight of criterion i .

S_i is the standard deviation of the data of alternatives to criterion i .

r_{ij} is the correlation coefficient between row i and column j .

Finally, the decision vector is obtained by establishing the weighted sums for each alternative; this is achieved by multiplying the result of each criterion within a scenario by the weight of that criterion. Then all scenario-weighted values for each criterion must be added; this would convert the decision matrix into a weighted decision vector. The one with the maximum or minimum value will be chosen as the winning alternative depending on whether the criteria are variables to be maximized or minimized. In the vector resulting from weighted sums (1). This calculation is shown in 3.3.

$$P_{ondi} = \sum_i^m \sum_j^n (W_i * X_{ij}) \quad (3.3)$$

The following figure 3.2 shows the conceptual diagram of the method to be applied.

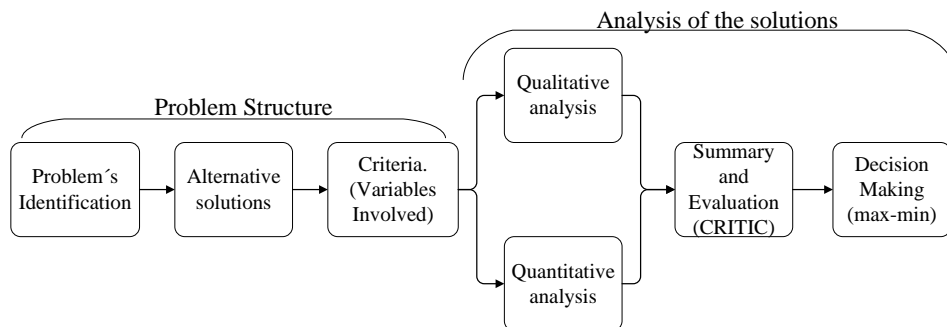


Figure 3.2: Graphical abstract of the research.

3.4 Analysis of Results

3.4.1 Optimal location and dimensioning of capacitors in microgrids using a multicriteria decision algorithm

The multicriteria optimization technique is applied to the solutions obtained for each analysis variable derived from the power flows calculated for each scenario. The algorithm assigns a specific compensation capacitance to one of the candidate nodes for analysis. The power flows are recalculated by injecting reactive power through this capacitance, yielding a result for each objective variable.

This iterative process continues until all proposed capacitances (discrete vector) have been considered for each candidate node. The Exhaustive Search algorithm (Brute Force) is justified in this analysis due to its precision, as it explores the entire set of feasible solutions. Moreover, the search space is relatively small, consisting of 14 different capacitances to be installed in 6 candidate nodes, resulting in 84 iterations. This number determines the length of the decision matrix columns. Additionally, since this is a problem related to future compensation planning, the computational time requirements are relatively simple.

The candidate nodes selected for compensation are exclusively load nodes and do not have any existing source of reactive power injection. The discrete vector of proposed capacitances to be installed is defined in steps of 50 kvar, ranging from 50 kvar to a maximum consumption of 700 kvar, representing the system's highest reactive power demand. The total cost per installation of compensating devices is shown in the equation 3.4.

$$Cost = \sum_{i=1}^n C |Q_i| \geq 0 \quad (3.4)$$

Cost of installation of the reactive power, considering that C=25 USD by kvar

$$50kvar \leq |Q_i| \leq 700kvar \quad (3.5)$$

Discrete vector of capacitances to be installed in steps of 50 kvar.

In addition to the problem's existing constraints, two additional considerations are made: Firstly, all nodes are considered equal candidates for connection, without any preference or variation in cost for installing the compensation devices. Secondly, the load is modeled as a constant power load, and the analysis focuses on the maximum demand scenario, ensuring that all variables meet their respective limits even in the minimum demand scenario. The variables calculated and verified for each demand scenario, in addition to the cost, are as follows:

$$P_{loss} = \sum_{i=1}^n (P_{gi}) - \sum_{i=1}^n (P_{ci}) \geq 0 \quad (3.6)$$

P_{gi} is the active power generated at node i , P_{ci} is the active power demanded in node i by each load connected, and P_{loss} are the total losses of active power in the microgrid. P_{gi} , P_{ci} and P_{loss} are given in kW.

$$\Phi = \arctan \frac{\sum_{i=1}^n Q_{ci}}{\sum_{i=1}^n P_{ci}} \quad (3.7)$$

Where Φ is the microgrid power factor angle measured in the bus where it is coupled to the system, P_{ci} is the active power (in kW) demanded by each load in node i , and Q_{ci} is the reactive power (in kvar) demanded by each load in node i .

$$DPV = \frac{\sum_{i=1}^n |V_{di} - V_i|}{n} \quad (3.8)$$

The average deviation of the voltage in the Microgrid, where n is the number of nodes of the System and V_i is the voltage in bus i in PU. (per unit).

$$DMV = \max \sum_{i=1}^n |V_{di} - V_i| \quad (3.9)$$

The maximum deviation of the voltage, where n is the number of nodes of the System, V_i is the voltage in bus i in PU. (per unit), and V_{di} is the desired voltage in bus i in PU.

$$THDv = \frac{\sum_{i=1}^n |V_{i,h}|}{V_{i,1}} \quad (3.10)$$

Total harmonic distortion index, where $V_{i,h}$ is the voltage component corresponding to harmonic h at node i , $V_{i,1}$ is the fundamental component of the voltage (1st harmonic) at node i , h is the maximum harmonic order to be considered in the calculation. As constraints to the problem, it is discarded solutions that, at maximum or minimum demand, do not meet the following limits:

$$0,95 \leq V_i \leq 1,05 \quad (3.11)$$

$$THDv_{max} \leq 5\% \quad (3.12)$$

Therefore, it is necessary to construct a decision matrix to determine the optimal dimensioning and location of the compensating device. The decision matrix comprises n columns representing the viable alternatives for all analyzed compensation options. These alternatives adhere to the criteria of being distinct, exclusive, and exhaustive, and they define different dimensioning and locations of the compensating devices at various nodes within the system. The m rows of the decision matrix represent the quantitative criteria defined by the variables used as objective functions. Based on the established decision criteria, the optimal option is selected by initially discarding all solutions that are inferior to others using the dominance criterion implemented in the algorithm. Additionally, solutions that violate the pre-defined constraints previously defined as limits for these variables are eliminated. Utilizing the decision matrix facilitates the evaluation and comparison of different compensation options, allowing for the identification of the optimal solution that fulfills the established criteria and constraints.

For the application and validation of the proposed methodology, an analysis of the location and optimal sizing of reactive power compensating devices in an electrical distribution system will first be carried out.

As a base case study for this evaluation, a very novel validated 15-bar Microgrid system of which the variables involved in this analysis are known. This test system has unbalanced loads, different voltage levels, a DC bus, non-linear loads, and distributed generation. All the details about the test system chosen as a case study can be found in (9), and the resolution with the algorithms is in (10).

Then, to apply this technique effectively, it is crucial to precisely determine the decision criteria and their quantifiable scales. The alternatives should then be evaluated based on their weights for each qualitative or quantitative criterion to form the eligible set. The subsequent step involves establishing a decision matrix to select the optimal solution, encompassing the decision criteria for the entire analyzed search space. Given that the system is relatively small, an Exhaustive Search algorithm will be implemented in this case study.

After obtaining the decision matrix, the solutions will undergo dominance analysis, eliminating any solutions inferior to others in all variables. Considering the weights assigned to each variable, the weighted sums technique will be employed for the multicriteria decision-making process regarding the best location and dimensioning alternative for compensating devices.

The description of the variables used in 5 is presented in 3.1, while 3.2 outlines the variables utilized in Algorithm 2. Subsequently, the following section explains the algorithms employed to solve the multicriteria problem of reactive power compensation. 5 focuses on allocation using the exhaustive search technique, while 6 describes the multicriteria decision technique under the proposed methodology.

Table 3.1: Variables of algorithm I.

Symbol	Description
n	Bus number
$Phase$	Number of phases
$Candidate_{bus}$	Number of candidate buses of the HMG
$Capacitor$	Vector of capacitances
$Comp - 6 \dots Comp - n$	Selection variable of the capacitor in bus n.
$Iterations$	Number of iterations to be performed.
$VoltageLL - pu - abc$	Data of phase voltages.
$Power - Losse - Total - n$	Data of total losses for the interactions of bus n.
$DPVS - n$	Average voltage deviation
$DVmax - n$	Maximum voltage deviation

Algorithm 5 Improved brute force for the n buses

```

1: Input:  $n, Candidate_{bus}, Capacitor$ 
2: Output:  $PF, P_{Losse}, DPVS, DVmax, THDv, Cost$ 
3: Initialize:  $Capacitor = [100e3 : 100e3 : 2000e3]; Comp_6 = 0; Comp_9 = 0; \text{until } Comp_n = 0; Phase = 3;$ 
4: For all  $i = 1 \text{ until } Candidate_{bus}$  if  $i = 1$  then  $n = 6; Comp_i = 1; Comp_i + 1 \text{ until } Comp_n = 0;$ 
5: For all  $j = 1 \text{ until size}(Capacitor)$   $Q_{cap} = Capacitor(j);$ 
    $Execute\ the\ model(HMGSimulink\ model); Read\ the\ DATA;$ 
6:  $Calculate\ V_{pu_i}, PF_i \text{ and } P_{Losse_i}; Calculate\ DPVS_i \text{ and } DVmax_i$ 
7: Save:  $V_{pu_i}, PF_i, P_{Losse_i};$ 
8: End for all
9: if  $i = 2$  then  $n = 9; Comp_i = 1; Comp_i - 1 \text{ until } Comp_n = 0; Repeat\ steps : 5 \text{ thru } 6;$ 
10: if  $i = 3$  then  $n = 10; Comp_i = 1; Comp_i - 2 \text{ until } Comp_n = 0; Repeat\ steps : 5 \text{ thru } 6;$ 
11: if  $i = 4$  then  $n = 11; Comp_i = 1; Comp_i - 3 \text{ until } Comp_n = 0; Repeat\ steps : 5 \text{ thru } 6;$ 
12: if  $i = 5$  then  $n = 12; Comp_i = 1; Comp_i - 4 \text{ until } Comp_n = 0; Repeat\ steps : 5 \text{ thru } 6;$ 
13: if  $i = 6$  then  $n = 14; Comp_i = 1; Comp_i - 5 \text{ until } Comp_n - 1 = 0; Repeat\ steps : 5 \text{ thru } 6;$ 
   endif; End for all;
14:  $VoltageLL_{puabc_n} = [VoltageLL_{puabc_1}, VoltageLL_{puabc_2}, \dots, VoltageLL_{puabc_i}];$ 
15:  $PF_{abc_n} = [PF_{abc_1}, PF_{abc_2}, PF_{abc_i}];$ 
16:  $Power_{Losse_n} = [P_{Losse_1}, P_{Losse_2}, P_{Losse_i}];$ 
17:  $PF_{abc_n} = [PF_{abc_1}, PF_{abc_2}, PF_{abc_i}];$ 
18: Return:  $V_{pu_n}, PF_{abc_n}, P_{Losse_n} \text{ and } PF_n;$ 

```

Table 3.2: Variables of algorithm II.

Symbol	Description
$win - case$	Winning case
N	Number of observations
$DPVS$	Average deviation of system voltage
$DVmax$	Maximum deviation of system voltage
$Power - Losse - Total$	Total losses of active power
$angle$	Power factor angle
$THDv$	Total harmonic distortion of the system
$Cost$	Costs of reactive power compensation
$DPVS - Pond$	Weight of the average voltage deviation
$DVmax - Pond$	Weight of the maximum voltage deviation
$Power - Losse - Total - Pond$	Weight of the total losses in the system
$angle - Pond$	Weight of the power factor angle
$THDv - Pond$	Weight of the Total Harmonic Distortion
$Costpond$	Weight of the compensation cost

Reactive power compensation has been a long-standing issue in electrical power systems. Numerous methodologies have been proposed to determine capacitor banks' optimal placement and power rating to meet quality requirements. Optimization algorithms allow for proposing the capacitor bank with the lowest reactive power demand, positioned in the most favorable location within the electric system. This challenge also extends to microgrids. The most common approach in distribution systems to compensate for reactive power is the installation of capacitor banks, which offer a simple and cost-effective solution to inject reactive power when needed. Some researchers also suggest adjusting transformer

Algorithm 6 Decision algorithm.

-
- 1: **Input:** $V_p u_n; PF_n; P_{Losse_n}$ and PF_n ;
 - 2: **Output:** win_{case} ;
 - 3: **Initialize:** $Cost = [1 : 50 : 700] * 25; DPVS_{Pond} = 0.2; DVmax_{Pond} = 0.4; Power_{Losse_{Total}_{Pond}} = 0.7; angle_{Pond} = 1; THDv_{Pond} = 1; Cost_{Pond} = 1.2; cont = 0; A = [DPVS_1, DPVS_2, \dots, DPVS_{n-2}, DPVS_{n-1}, DPVS_n; DVmax_1, DVmax_2, \dots, DVmax_{n-2}, DVmax_{n-1}, DVmax_n; Power_{Losse_{Total}_1}, Power_{Losse_{Total}_2}, \dots, Power_{Losse_{Total}_{n-2}}, Power_{Losse_{Total}_{n-1}}, Power_{Losse_{Total}_n}; acos(PF_1), acos(PF_1), acos(PF_{n-2}), acos(PF_{n-1}), acos(PF_n); THDv_1, THDv_2, THDv_{n-2}, THDv_{n-1}, THDv_n; Cost_{Cost_{Cost_{Cost_{Cost_{Cost}}}}}]$;
 - 4: **For all** $u = 1$ **until** $dimension(coders)$
 - 5: **if** $(1 - A(2, u)) < 0.95$ (**VoltageLimitConstraint**)
 - 6: $A(:, u) = []$; (**Undesired results are eliminated**)
 - 7: **End for all**; **End for all**;
-

capacities to measure reactive power compensation, given their high reactive power consumption as highly inductive machines.

Analogous to traditional electric systems, determining the appropriate bus for connecting a compensation bank with the least reactive power requirement is crucial to achieving desired power quality conditions. It is essential to consider both maximum and minimum demand scenarios since a candidate solution that works well in an isolated microgrid during peak demand may not be suitable during periods of low demand without connection to the main grid if it violates any power quality conditions considered in the microgrid.

As part of the exhaustive search multi-objective algorithm, a predefined set of reactive power values (candidates) and bus options (candidates) for connecting the bank are established. However, selecting a capacitor that injects a discrete amount of reactive power at a bus may sometimes be optimal. A larger or smaller reactive power value could provide better power quality. Such reactive power values may have yet to be considered among the predefined candidates. Consequently, only discrete and commercially available capacitive values are typically considered, while results with continuous capacitive values are disregarded.

There are alternative proposals for reactive power compensation in electric power systems, such as SVC (Static Var Compensator) based on thyristors, which regulate the conduction time in coils or capacitors (Thyristor Controlled Reactor, TCR, and Thyristor Switched Capacitors, TSC). Another solution involves compensation using converters that rely on static switches like the IGBT. An example is the STATCOM (Static Synchronous Compensator), which injects reactive power in a non-discretized manner.

These proposals rely on the operation of power electronics equipment. In the case of SVC, the thyristor-based process introduces additional harmonics along with the fundamental frequency, often necessitating the inclusion of filters (42), (43). The control systems of STATCOM can be more complex, making it a justifiable choice when high-speed control is a critical factor.

This research focuses on a specific case study (3) that has been chosen due to its high realism and comprehensiveness, making it an ideal subject for analysis in the context of reactive power compensation. Among numerous options, this microgrid case study provides extensive data on electrical variables, allowing for a practical and accurate analysis in scenarios where conflicts arise between the variables under consideration. The microgrid combines single-phase and three-phase loads, including non-linear and unbalanced loads. It further adds to its complexity and relevance in studying reactive power compensation. At bus 9 of the system, a non-linear load exists as a pulse-width modulated (PWM) three-phase rectifier. This rectifier operates at a commutation frequency of 4080 Hz, with

a modulation index of 0.8. It is important to note that the rectifier operates in an open-loop configuration, maintaining a fixed angle throughout its operation. The Microgrid consists of a total of 7 transformers and 14 distribution lines. Out of these transformers, 2 serve as step-down transformers, connecting the medium voltage grid to the low voltage grid. Another 3 step-down transformers facilitate the interface at low voltage with the distributed generation sources. A step-down transformer is also responsible for connecting to the Critical Consumption Point (CCP), while a step-up transformer links the Diesel generator to the medium voltage grid. Regarding distribution lines, 7 lines are operating at medium voltage, and 7 are operating at low voltage, making 14 distribution lines in the Microgrid. The one-line diagram of this case study is shown in figure 3.3.

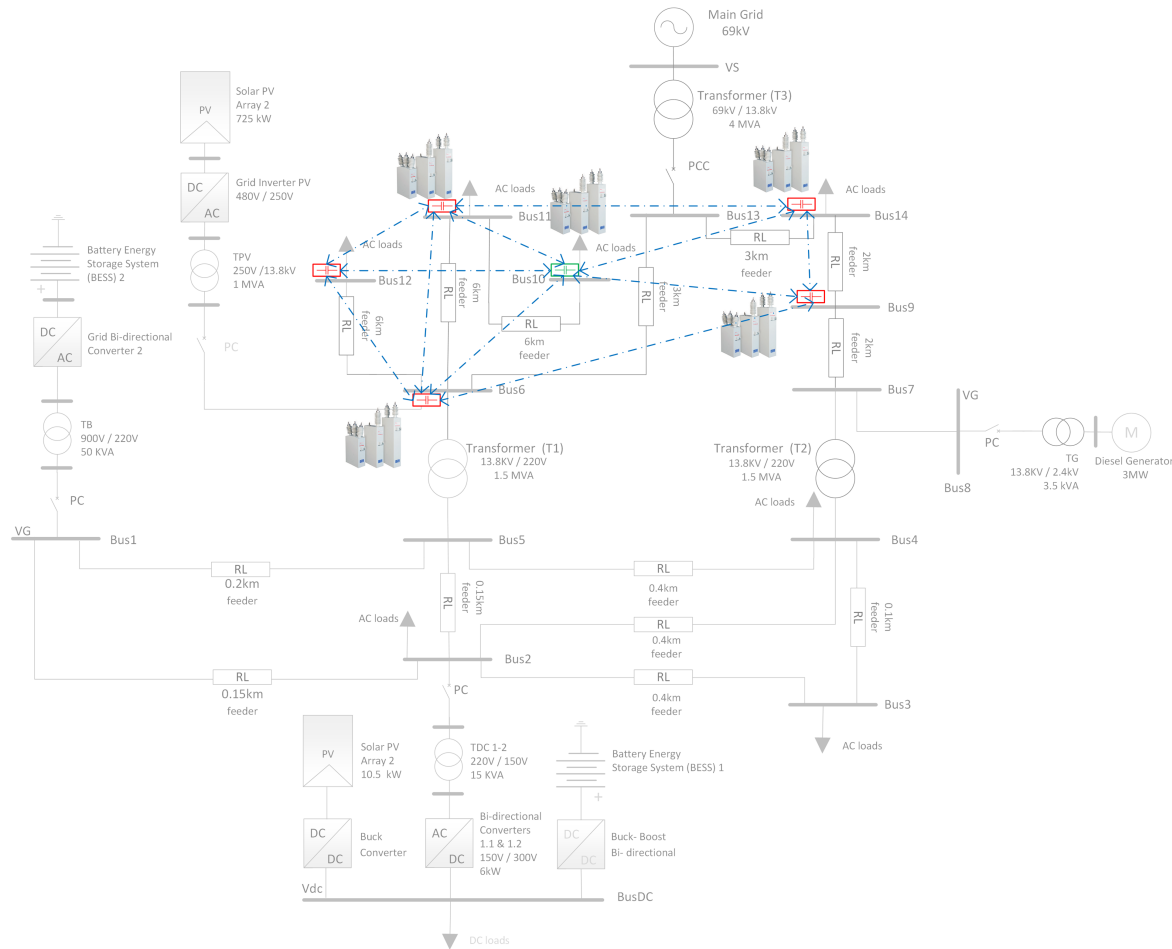


Figure 3.3: One-line diagram of the microgrid case study.

The proposed methodology, incorporating the Exhaustive Search algorithm for power flow evaluation and simulation with connected reactive capacitances and

the Multicriteria decision algorithm for determining the optimal dimensioning and location of the capacitor bank in the microgrid, has yielded groundbreaking results, which will be discussed in this section.

Figure 3.4 illustrates the normalized performance of the variables (criteria) for each of the 84 compensation scenarios, represented in a range-normalized matrix. Visually, it can be observed that similar reactive compensations yield similar behaviors across the variables, albeit differing based on the bus to which the reactive power compensation is connected. Each bus exhibits distinct outcomes.

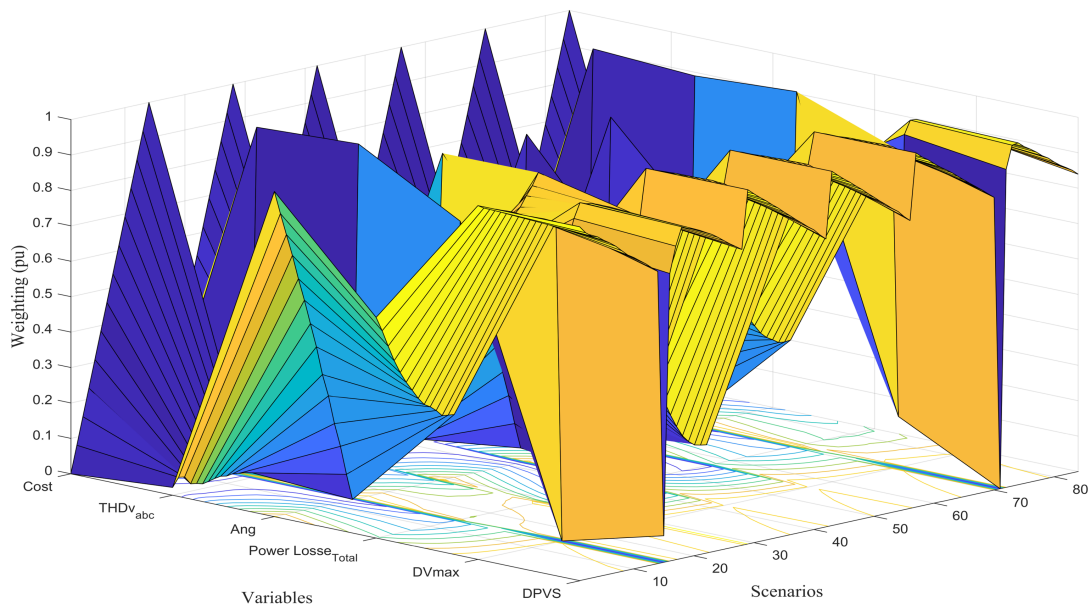


Figure 3.4: Normalized criteria for reactive power compensation scenarios.

A weighted calculation is performed per the proposed model's methodology using the normalized criteria matrix obtained for each compensation scenario. The normalized unit criteria for each variable and their corresponding weights are summed, resulting in a new vector known as the weighted sums. Figure 3.5 depicts the outcome of this vector, showcasing the weighted criteria for each compensation scenario.

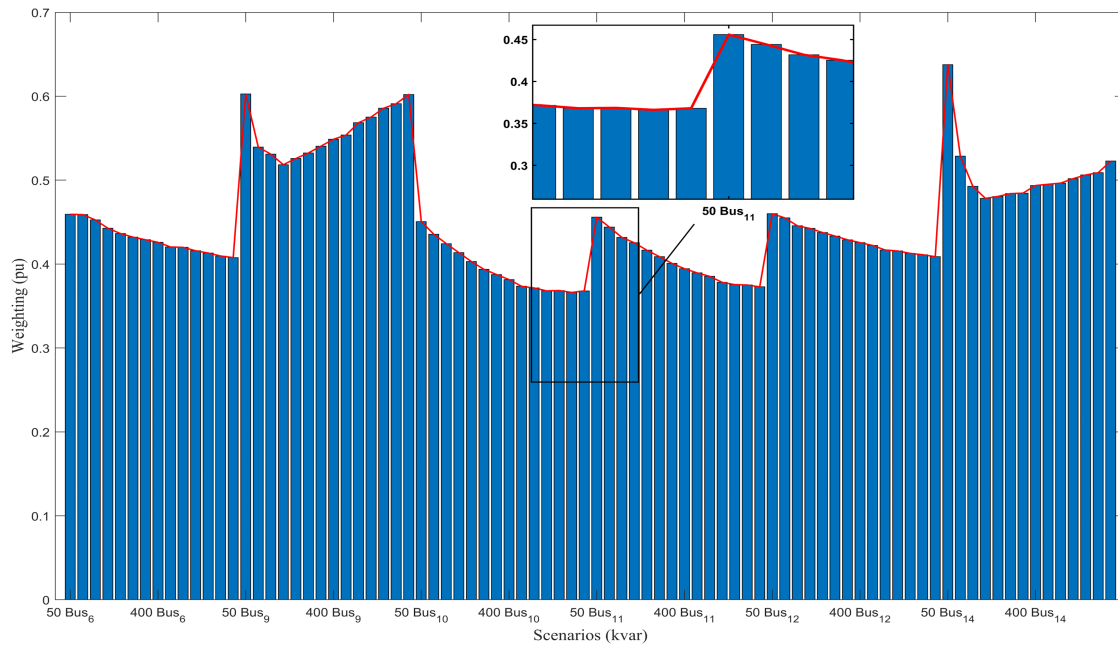


Figure 3.5: Weighted sums for each reactive power compensation scenario.

Scenario 41 emerges as the winning alternative, characterized by a reactive capacitive compensation of 650 kvar connected to bus 10 in the microgrid. The x-axis represents the capacities and locations of the capacitor. Having identified the multicriteria winning alternative (650 three-phase kvar at bus 10), each variable is analyzed to ensure compliance with operational limits (constraints) in both maximum and minimum demand load scenarios. It is worth noting that any individual results that fail to meet the constraints were eliminated during the decision algorithm, as outlined in step 4 of the algorithm.

In the analysis case where THD is not considered an objective criterion within the multicriteria optimization, Figure 3.6 illustrates the solutions represented by weighted sums for each of the 84 reactive power compensation scenarios. This analysis focuses on five variables, excluding THD, to demonstrate the inherent conflict between these variables and to highlight potential optimal outcomes that may not be truly optimal.

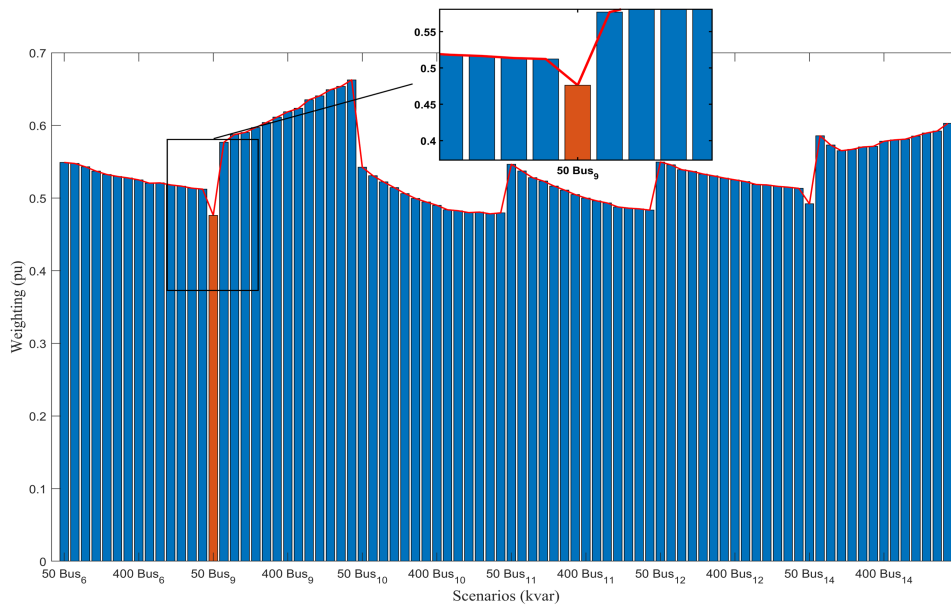


Figure 3.6: Weighted sums for each scenario of reactive power compensation without considering the THD as an objective criterion. Non-coherent result.

It is worth noting that one particular result appears "apparently" favorable and closely resembles the winning alternative previously discussed. This outcome is achieved with a minimum compensation of 50 kvar on bus 9. However, this seemingly positive result is undesired due to harmonic distortion resulting from non-linear loads at that bus. This situation creates a conflict with the THD variable. This undesired result emphasizes the problem addressed in this research, highlighting the necessity of treating reactive power compensation as a multicriteria optimization problem that accounts for variables such as harmonic distortion. It underscores the importance of considering multiple criteria to obtain truly optimal solutions.

The conflict between harmonic distortion (THD) and the Maximum Voltage Deviation variable can be observed in Figure 3.7. In this analysis, THD is excluded to independently assess each compensation scenario for bus 9. The harmonic distortion profile of the microgrid under study is compared with the Maximum Voltage Deviation variable, one of the objectives in this specific analysis comprising five objective functions.

Figure 3.7a) illustrates the THD variable for each of the 14 buses in the microgrid across the 14 compensation scenarios considered for bus 9. On the other hand, Figure 3.7b) displays the Maximum Voltage Deviation for the entire microgrid across the same 14 compensation scenarios for bus 9.

This analysis reveals a winning alternative with a minimum compensation of

50 kvar at bus 9. However, this result is undesirable due to an increase in voltage profiles caused by the harmonic distortion resulting from the connection of non-linear loads. It demonstrates the necessity of incorporating the THD variable as a weighted criterion in the multicriteria decision process. The effect of the minimum value of the maximum voltage deviation is driven by high total harmonic distortion, emphasizing the importance of considering THD in the decision-making process.



Figure 3.7: (a) THD per bus in maximum demand with compensation in bus 9 and (b) Maximum voltage deviation with compensation in bus 9 without considering the THD as an objective criterion.

Figure 3.8 illustrates the steady-state voltage waveform with 50 kvar compensation at bus 9. The voltage waveform undergoes significant distortion due to the non-linear load components present at this bus. The harmonic distortion effect on the voltage waveform led to an undesired winning alternative in the multicriteria decision process. This scenario resulted in minimum cost and minimum value of maximum voltage deviation due to the distortion-induced increase in peak voltage. The installed capacitance in this scenario had values close to the system's resonance frequency.

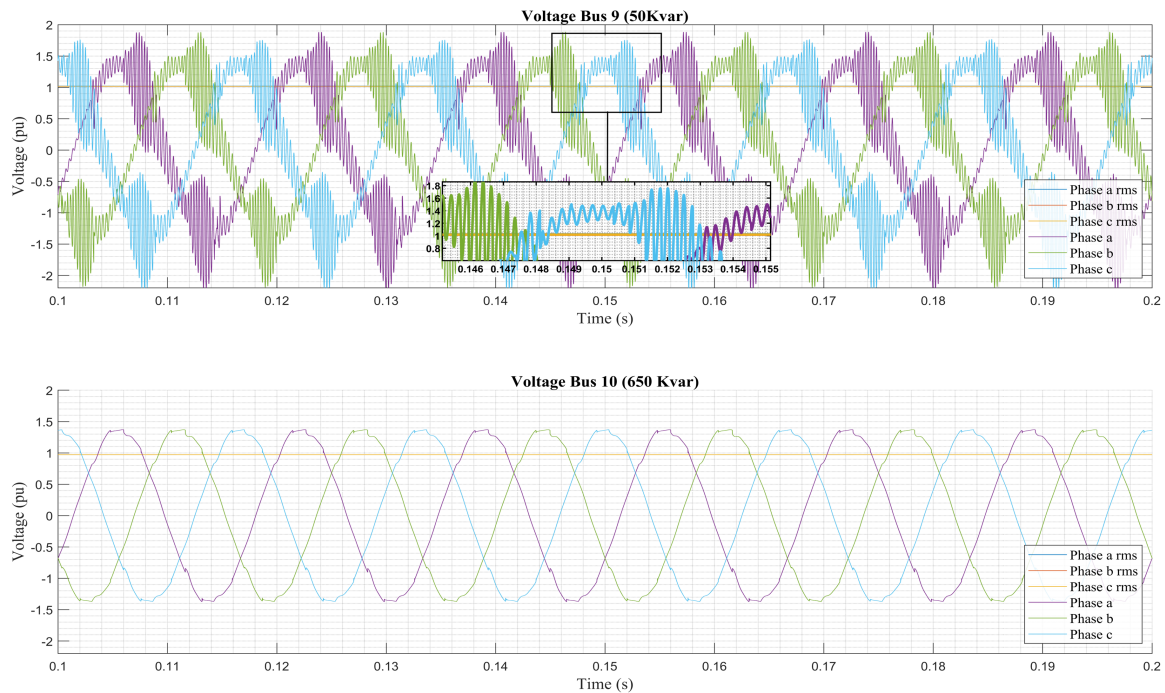


Figure 3.8: Waveforms comparison: (above) voltage at bus 9 in the 50 kvar candidate compensation and (down) voltage at bus 10 in the 650 kvar winning compensation.

This research focuses on a comprehensive case study encompassing various variables impacting a hybrid microgrid's quality and efficiency. These variables include unbalanced, non-linear, and maximum and minimum demand scenarios. The objective is to determine the optimal reactive power compensation using capacitor banks. Previous studies have approached reactive compensation as a single-objective optimization problem. However, improving the voltage profile can impact other variables contributing to an electrical system's power quality. Therefore, it is crucial to simultaneously consider variables such as voltage profile, active power losses, global power factor, and harmonic distortion rate when deciding on capacitance, dimensioning, and compensation cost.

In this work, we formulate the reactive power compensation as a multicriteria optimization problem. The algorithm considers two demand scenarios and calculates power flows with discretized compensation using the Exhaustive Search algorithm. The algorithm determines the optimal locations for discretized capacitances among candidate buses. Based on the preliminary results, a second algorithm is developed to assign weights to each variable, tailored for a minimization criterion. As a result, each compensation scenario is assigned a weighted solution, with some scenarios discarded based on the dominance criterion. The final step is to choose

the optimal solution that satisfies the defined criteria. This methodology ensures the compensation solution aligns with the correct operational requirements for reactive power compensation in distribution systems with distributed resources.

Additionally, a case is analyzed where the total harmonic distortion (THD) is not considered an objective criterion. The results highlight the conflicts between the analysis variables within the studied system. This finding justifies and supports the proposed methodology, demonstrating the importance of considering more quality and efficiency variables than previously addressed by other researchers.

Overall, the proposed methodology provides innovative solutions that underscore the need to approach the problem of reactive power compensation as a multicriteria problem, considering a comprehensive set of quality and efficiency variables.

The resolution with the algorithms is in (10).

3.4.2 Optimal location of reclosers in electrical distribution systems considering multicriteria decision

The proposed multicriteria technique will also be evaluated for a reliability problem in distribution systems (level 2).

This section introduces a novel methodology for optimizing the placement of reclosers in electric distribution systems. The proposed approach employs a multicriteria analysis to assess the reliability indicators at the distribution level (level 3) by generating scenarios using pseudo-random variables. The reliability indicators considered in this study include the System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI), and Average Energy Not Supplied (AENS).

Deterministic random generation is utilized within specified ranges associated with each analysis variable, such as failure rates of elements and loads, failure duration, number of customers per load point, mean power consumption at each load point, and others. The reliability indicators are calculated for every potential location of a recloser in the candidate primary sections, resulting in a decision matrix that is normalized and weighted using the CRITIC method to determine the optimal location based on a minimum criterion.

The analysis is repeated N times using the Monte Carlo method to generate scenarios, thereby establishing the probability of occurrence for each winning alternative. The final optimal location of the first recloser within the distribution system is selected. The methodology also includes switching coordination, repeating the analysis described earlier to determine the location of a second recloser, considering that the first recloser has already been identified as a winning alternative in generating numerous scenarios.

The proposed methodology applies to any distribution system and allows for analyzing multiple reclosers, considering cost constraints. Comprehensive programming is implemented in the Matlab software environment to carry out the analysis. The results successfully address maneuver and switching tests by minimizing all reliability indicators at the distribution level.

This methodology effectively resolves knowledge gaps in reliability studies by filling in data gaps using pseudo-random variable generation and identifying recloser locations that optimize all reliability criteria within the distribution system.

The reliability analysis is conducted in different levels, with level 1 focusing on generation sufficiency, level 2 considering generation and transmission line availability, and level 3, the main focus of this research, assessing the reliability in electric energy distribution. In level 3, the evaluation is performed on the distribution systems rather than individual users, as consumers are connected to various load points (transformers) that are affected differently by failures in the distribution system.

Due to this impact variation, it is not feasible to devise a single function for calculating reliability indicators across all distribution systems. The analysis heavily relies on the topology of the electric distribution network and how failures in different network elements affect each load point.

Advancements in information technologies have facilitated reliability evaluation using iterative and more complex mathematical techniques, improving prediction accuracy. One such technique is the well-known Monte Carlo method, which calculates the probability of a specific result by analyzing numerous randomly generated scenarios. Analyzing many scenarios makes the process more efficient and enables accurate determination of the probability of a particular scenario occurring.

Many researchers who have addressed reliability evaluation highlight the challenge posed by the availability of historical data required to establish failure rates and duration times for the elements constituting the distribution system. Due to the need for such data, many reliability studies resort to measures provided by manufacturers and typical behavioral ranges.

The proposed approach utilizes the Monte Carlo method, which generates pseudo-random numbers within predetermined ranges. These pseudo-random variables create multiple scenarios in which failure rates and durations for each system element are simulated. The Monte Carlo method provides a relative error of $1/N$, where N represents the random variable's number of scenarios or components. It's important to note that the relative error decreases as the number of scenarios increases.

The Monte Carlo method is a powerful tool for this analysis as it allows for a more straightforward determination of the limits within which the analysis variables, such

as failure rates and durations of system elements, are likely to fall. This simplifies the central challenge of reliability analysis: the absence of precise data on these variables. The analysis can proceed effectively despite the lack of detailed data by utilizing the Monte Carlo method.

The multicriteria optimization technique is utilized to analyze the reliability indicators obtained for each considered scenario. The algorithm assigns specific locations to the switching devices (reclosers) in the candidate primary sections, excluding the final sections of the radial circuit that are already determined by switching load points (transformers).

The reliability indicators (SAIFI, SAIDI, CAIDI, AENS) are recalculated for each switching assignment, generating an individual scenario result for each objective criterion. This iterative process continues until all proposed candidate primary sections have been evaluated. As a result of this analysis, a discrete vector is obtained, containing solutions corresponding to each scenario.

The decision matrix is then constructed, with each reliability indicator represented in a column (criteria) for each solution vector of each criterion. The Exhaustive Search (Brute Force) algorithm considers all candidate scenarios (primary sections that do not terminate the circuit).

It guarantees the exploration of all feasible scenarios and ensures an optimal solution. Switching connection scenarios in the final sections of the distribution system are disregarded as they are already covered by the transformer switching. Tests have shown that the probability of these scenarios becoming the winning alternative is very low unless the failure rate in that section is exceptionally high and the load point has the highest number of users in the entire distribution system.

The number of scenarios determines the length of the decision matrix rows, where rows correspond to scenarios and columns represent criterion results. However, the decision matrix can be constructed row-wise or column-wise without affecting the subsequent analysis of weighted sums. Furthermore, computational time requirements are reasonable since this is a future planning problem for switching locations.

Establishing the decision matrix is essential to obtain individual results per scenario based on the optimal switching locations. The n rows of the decision matrix represent suitable alternatives among all switching location options, adhering to the criteria of being distinct and exclusive. The m columns represent the criteria (reliability indicators) as objective functions. The optimal option is selected based on the established decision criteria, eliminating any solutions inferior to others according to the dominance criterion.

The proposed methodology was evaluated as a case study using the 15-bus IEEE electric distribution test system operating at medium voltage. This test system was

obtained from the IEEE database. The system comprises 14 primary sections and 14 load points. Among these sections, section P1 already has a general recloser (R) that activates in the event of any interruption in the primary sections of that circuit.

Additionally, out of the 14 primary sections, the seven end sections (P4, P6, P7, P9, P12, P13, and P14) are excluded as candidate sections for recloser installation. Considering that a recloser is already installed in section P1 and that the end sections solely supply a load point with its protection at the transformer, the remaining candidate sections for recloser installation are P2, P3, P5, P8, P10, and P11. Extensive simulations have shown that the probability of these alternatives becoming the winning option could be much higher.

In this case study, the 14 load points (distribution transformers) are denoted by the letter (S) in the single-line diagram. Each load point is equipped with an independent switch that activates in case of the respective secondary system failures. The 15 buses of the system are numbered in the single-line diagram. Figure 3.9 illustrates the detailed single-line diagram based on the predefined conditions in the 15-bus IEEE test system.

IEEE 15-bar system

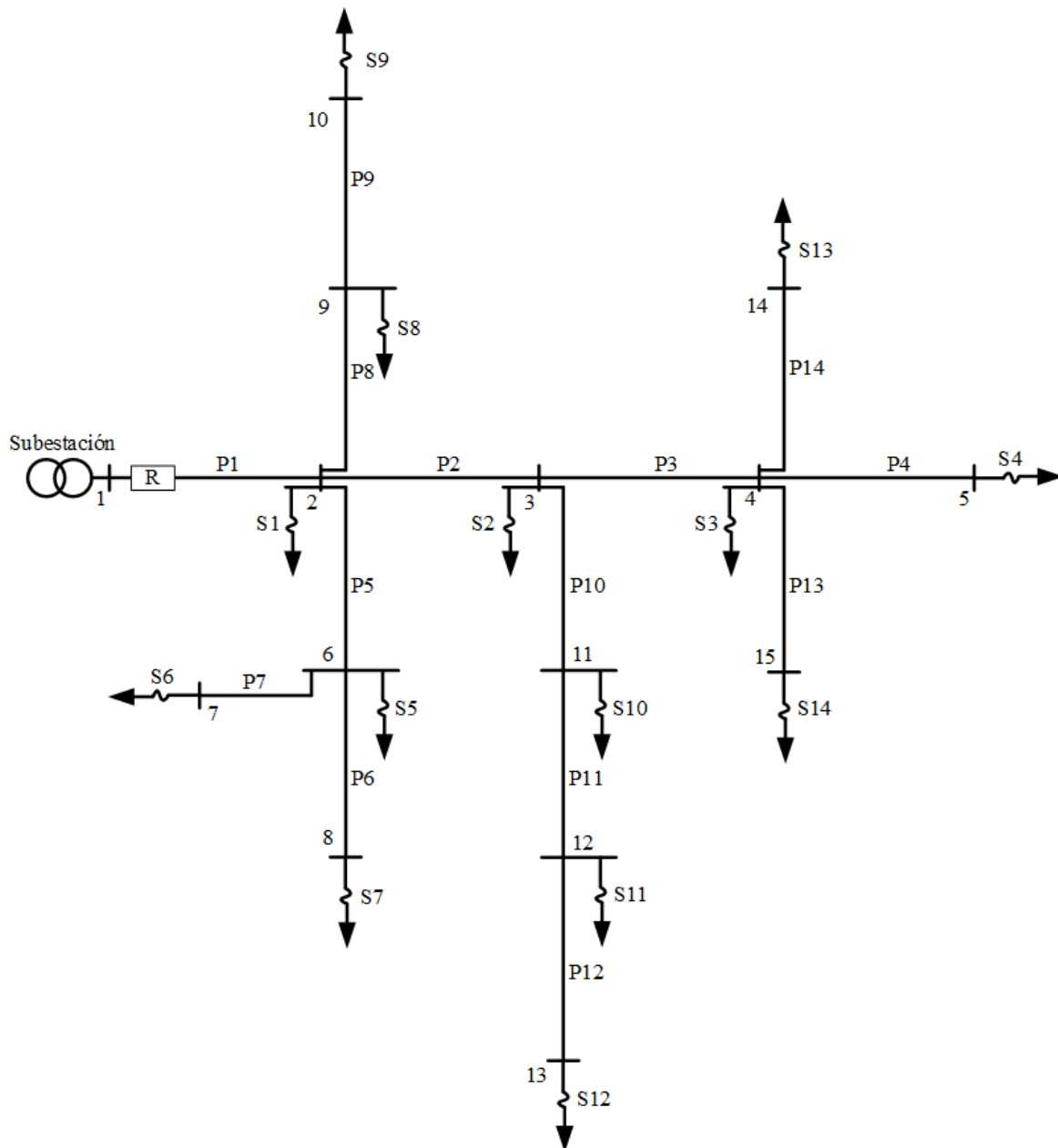


Figure 3.9: Graphical 15-bus IEEE test system.

The initial step involves establishing the random values for the base case and calculating the reliability indicators without considering any additional switching location apart from the existing one in P1. The obtained results for the pseudo-random analysis variables and reliability indicators will be presented for this base case.

In Figure 3.10, data of failure rates and duration times of these failures are displayed for each load point in the test distribution system. These data were generated using pseudo-random variables within defined and adjustable ranges.

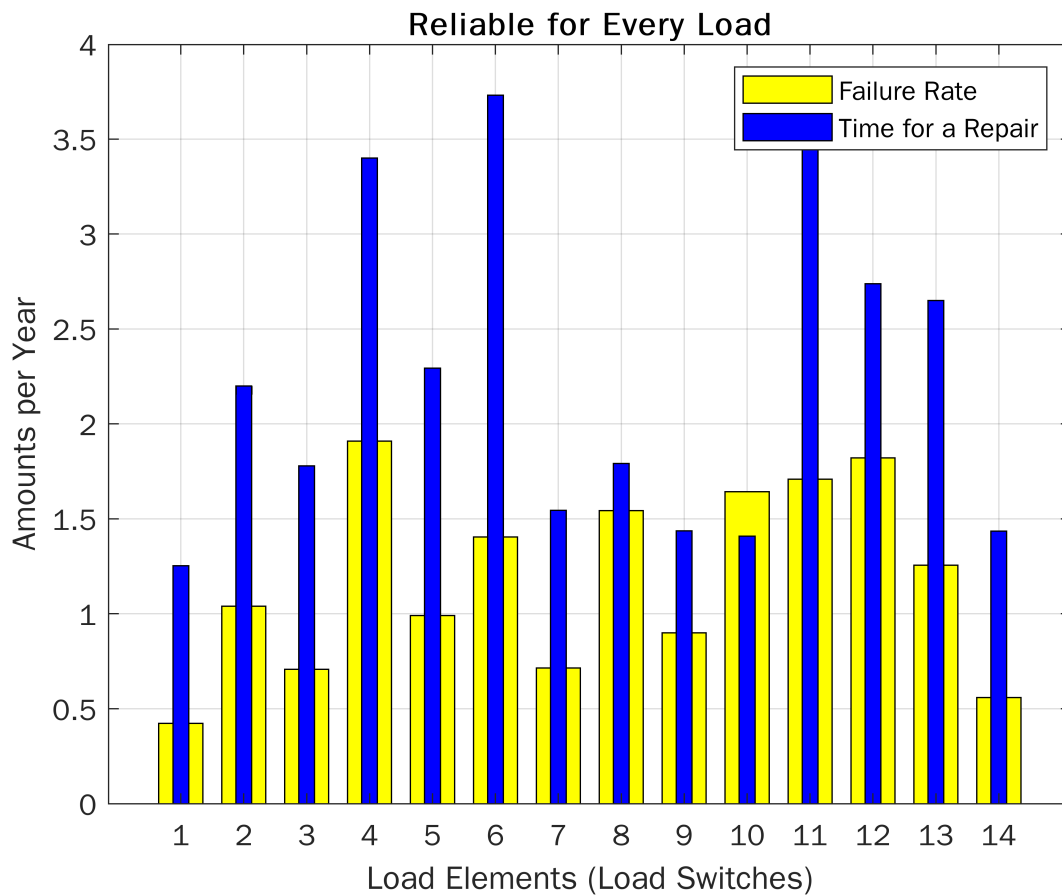


Figure 3.10: Fault data per year and fault repair times for each test system's load point (transformer).

Additionally, Figure 3.11 illustrates the failure rates of each primary element (sections P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, and P14), while Figure 3.12 presents the interruption repair times for these elements. These data were also generated using pseudo-random variables within adjustable ranges.

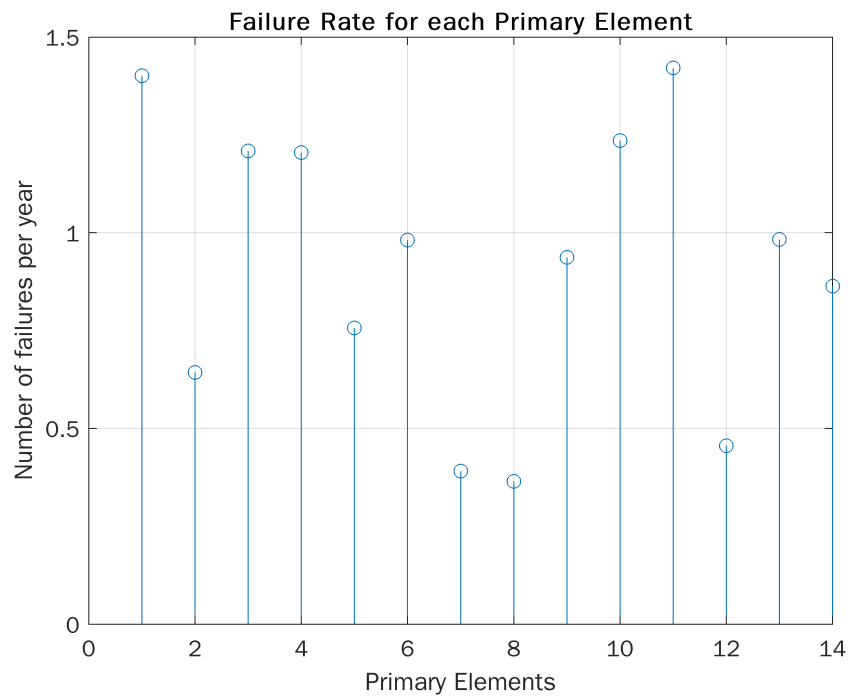


Figure 3.11: The failure rate for each primary element.

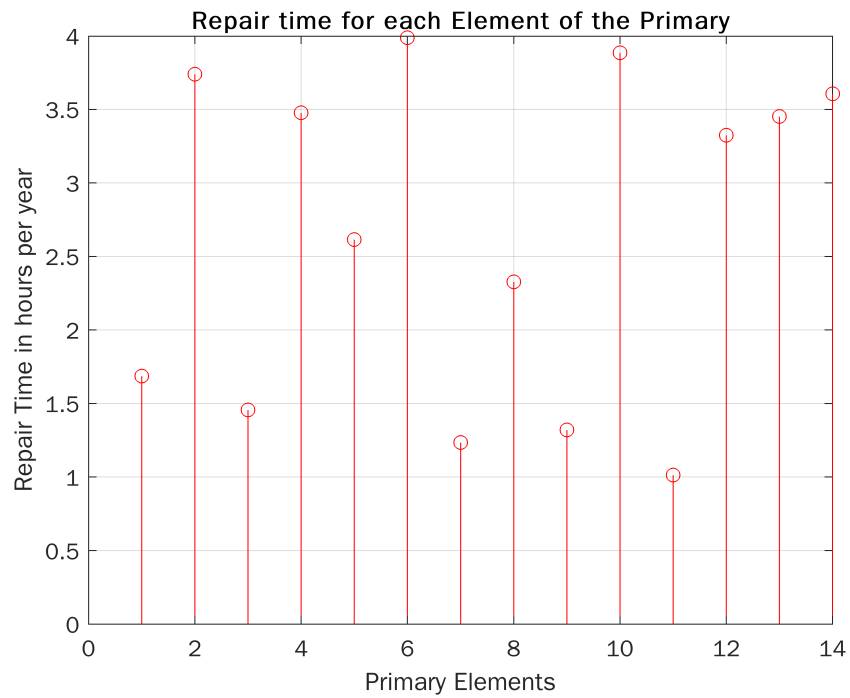


Figure 3.12: Repair time for each element of the primary.

The proposed example focuses on residential users; however, the model can

be adapted to incorporate accurate data if available. For the initial conditions of the problem, information regarding the number of users and their average consumption is known. Figure 3.13 provides details on the number of residential consumers connected to each transformer and the average power consumption at each load point (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, and S14).

The analysis employs a counting technique to determine the potential occurrences of failures affecting each user (load point) based on the input data. It calculates the total number of failures per year that can impact a user connected to a specific transformer (load point), considering the failure rates at each load point and primary section. This information is visualized in Figure 3.14.

Failures affecting users can occur either through the operation of their transformer switch or the existing recloser (P1) interrupting the power supply to the entire circuit when a failure occurs in any primary section of the test system. Additionally, considering all potential failures in the design and their respective repair times, the total duration of losses experienced by an individual user throughout the year is determined by summing up the repair times of all system failures that could interrupt their service. Figure 3.15 provides an overview of the total duration of losses that may impact each user in a given year.

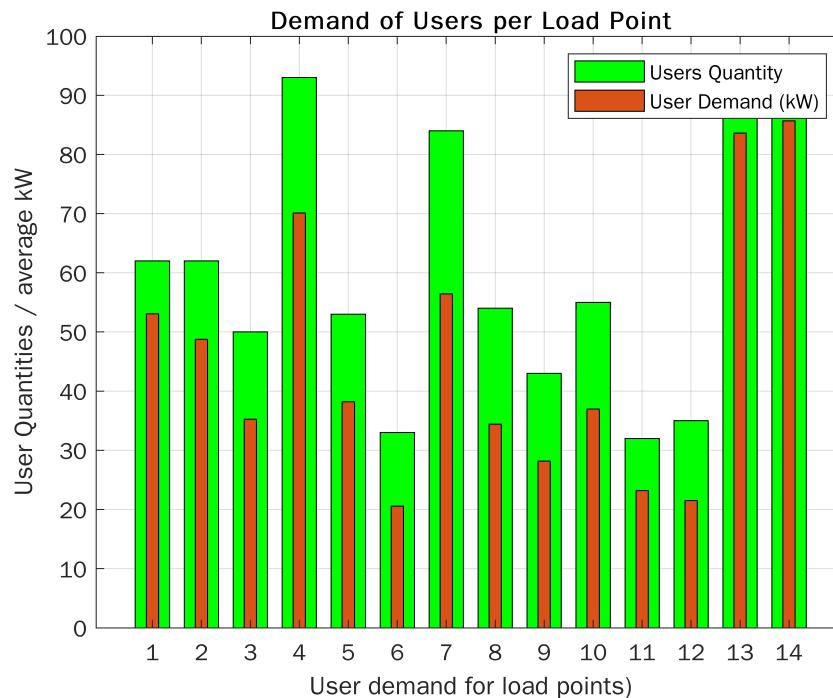


Figure 3.13: Number of power consumers per electric load point and average total consumption per load point.

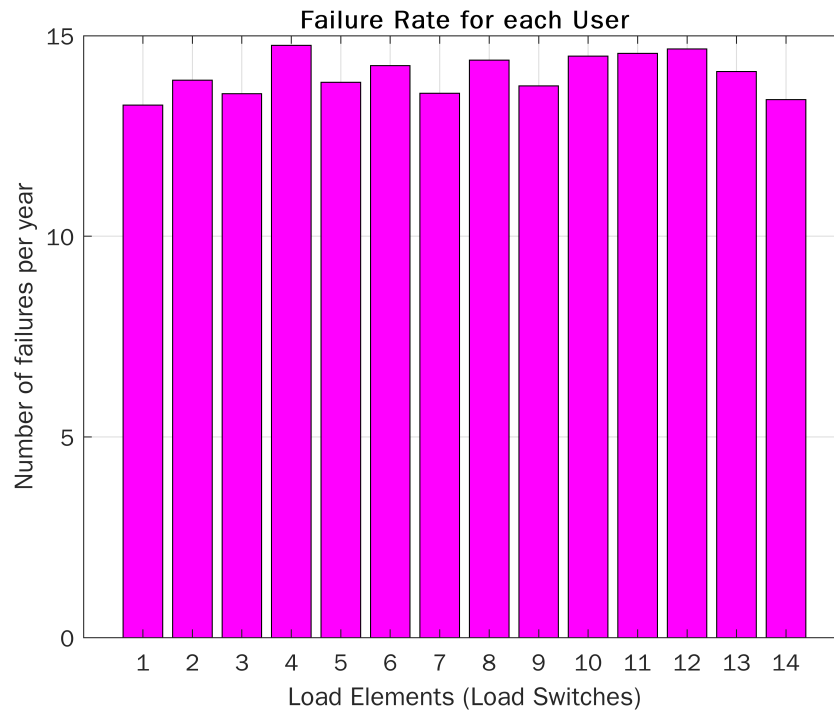


Figure 3.14: The total failure rate for each system user (load point).

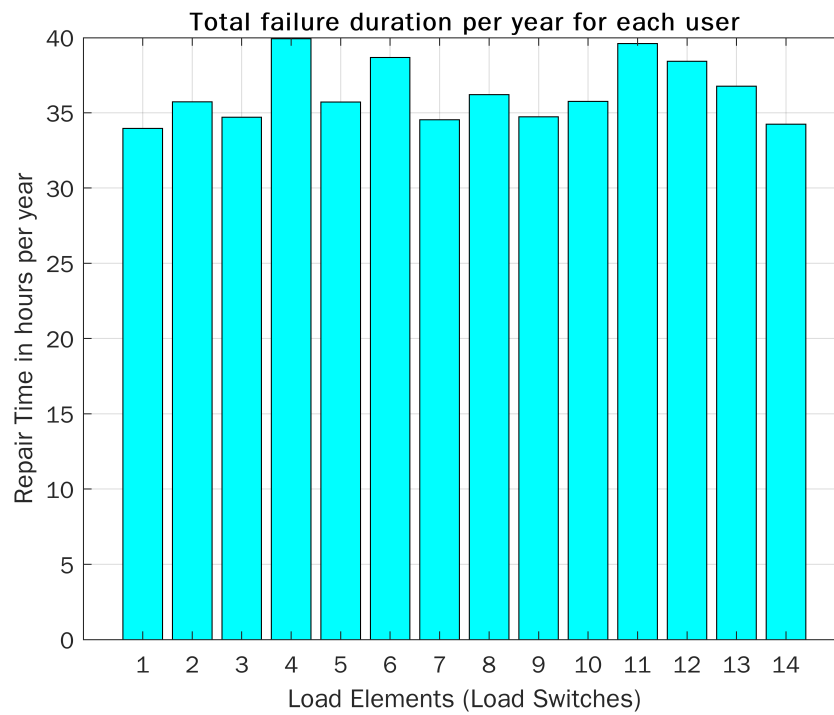


Figure 3.15: Total failure duration per year for each user.

By analyzing the data on total failure rates and the corresponding total duration of failures that may impact a specific user in the test distribution system over a year, we can calculate the average time of each user's system failure (load point). This calculation is derived from dividing the pseudo-random variables representing the total duration of failures by the total failure rate in a year per user. The average duration time for a single system failure for each user can be seen in Figure 3.16.

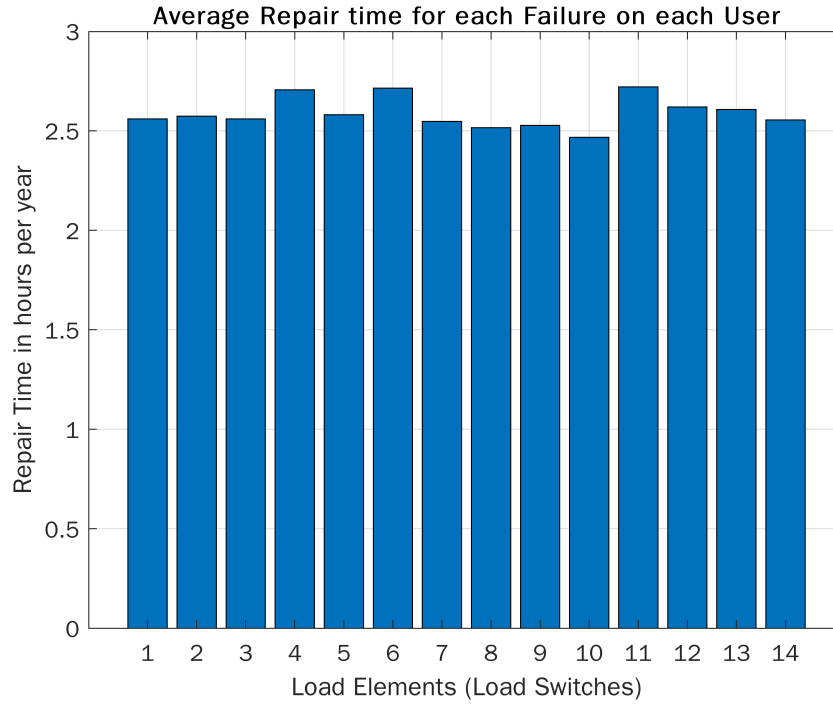


Figure 3.16: The average duration of a single failure for each system user.

By utilizing these given initial conditions, one can calculate the reliability indicators (SAIFI, SAIDI, CAIDI, and AENS) for the tested electric distribution system, assuming the presence of a lone recloser at P1 (4).

$$SAIFI = \sum_{i=1}^n \frac{\lambda_i N_i}{Nt} \quad (3.13)$$

SAIFI represents the average number of outages experienced by each customer within a year in a specific study system, where λ_i denotes the failure rate, N_i represents the number of users per location, and Nt indicates the total number of users served. For the specific study case, the SAIFI value is 13,0018 yearly failures.

SAIDI: System Average Interruption Duration Index.

$$SAIDI = \sum_{i=1}^n \frac{U_i N_i}{Nt} \quad (3.14)$$

SAIDI is a reliability indicator that quantifies the average interruption time experienced by customers in a given location for a year. It is typically measured in time units, commonly hours. In the calculation of SAIDI, N_i represents the number of clients in location i , U_i represents the yearly interruption time for location i , and Nt indicates the total number of users served. For the specific study case, the SAIDI value is 31,0908 hours of failures per year.

CAIDI: Customer Average Interruption Duration Index.

$$CAIDI = \frac{\sum_{i=1}^n U_i N_i}{\sum_{i=1}^n \lambda_i N_i} = \frac{SAIDI}{SAIFI} \quad (3.15)$$

CAIDI is a reliability indicator that measures the average interruption duration experienced by any client in a given system. It is typically expressed in time units such as minutes or hours. CAIDI can be interpreted as the average restoration time, representing the time it takes to restore power to a customer after an interruption. For the specific study case, the CAIDI value is 2,3913 hours per failure.

AENS: Average Energy Not Supplied.

$$AENS = \sum_{i=1}^n kW_i U_i \quad (3.16)$$

AENS is a reliability index utilized in electric power systems to quantify the average energy not supplied per user. It measures the amount of energy, typically expressed in kilowatt-hours (kWh), that is not delivered to each customer on average. For the specific study case, the AENS value is 24,9538 kWh/year for each user (independent consumer) of the test system.

Based on the analysis of the four indicators, the findings indicate that the system lacks reliability. To address this issue, appropriate measures should be implemented to identify the optimal locations for additional switching. This strategic placement of switches would effectively reduce overall failure rates and system restoration times, thereby minimizing the values of the reliability indicators.

This optimization study will examine the optimal placement of an additional recloser and the one already present at (P1). The previous calculations will be simulated under various scenarios for multicriteria analysis. Each scenario represents the placement of an additional recloser in candidate primary sections that are not circuit end sections. The following scenarios will be considered: Scenario 1: Recloser at P2, Scenario 2: Recloser at P3, Scenario 3: Recloser at P5, Scenario 4: Recloser at P8, Scenario 5: Recloser at P10, and Scenario 6: Recloser at P11. These simulations aim to assess the impact of each scenario on the calculated values under the initial conditions.

The following algorithm enables the evaluation of reliability indicators in each proposed scenario and determines the optimal location using the multicriteria decision method described earlier.

```

1 clear all; clc;
2 tic
3 Barras=15; % Sistema IEEE de prueba
4 Barras_Carga=14;
5 Troncales_Primarios=14;
6 N=100000;
7 error=1/sqrt(N)
8 for x=1:1:N
9 Elementos=['S02';'S03';'S04';'S05';'S06';'S07';'S08';'S09';'S10';'
    S11';'S12';'S13';'S14';'S15';'P01';'P02';'P03';'P04';'P05';'P06';
    'P07';'P08';'P09';'P10';'P11';'P12';'P13';'P14'];
10 a = 0.3; % Minimum number of failures for Primary Trunk Elements
11 b = 1.5; % Maximum number of failures for Primary Trunk Elements
12 a1 = 0.4; % Minimum number of failures for charging points (
    transformers)
13 b1 = 2.3; % Maximum number of failures for charging points (
    transformers)
14 Tasa_Fallas_Troncales = (b-a).*rand(Troncales_Primarios,1) + a;
15 Tasa_Fallas_Cargas = (b1-a1).*rand(Barras_Carga,1) + a1;
16
17 c = 1; % Minimum repair time for Elements
18 d = 4; % Maximum repair time for Elements
19 r_Troncales = (d-c).*rand(length(Tasa_Fallas_Troncales),1) + c;
20 r_Cargas = (d-c).*rand(length(Tasa_Fallas_Cargas),1) + c;
21 U_Troncales=Tasa_Fallas_Troncales.*r_Troncales; % Duration of
    Interruptions by Primary Elements
22 U_Cargas=Tasa_Fallas_Cargas.*r_Cargas; % Duration of Interruptions
    by Load Elements
23 r_promedio=mean(U_Cargas./Tasa_Fallas_Cargas);
24
25 e = 0.6; % kW/Usuario (Minimum consumption)
26 f = 0.9; % kW/Usuario (Maximum consumption)
27 Rango_Consumo = (f-e).*rand(Barras_Carga,1) + e;
28 g = 25; % kW (Minimum number of Users per charging point)
29 h = 100; % kW (Maximum number of Users per charging point)
30 Cantidad_Usuarios=randi([g h],1,Barras_Carga)';
31 Demanda_Usuario = Cantidad_Usuarios.*Rango_Consumo;
32
33 Total_Consumidores=sum(Cantidad_Usuarios);
34
35 % Analysis of all scenarios for the connection of two additional
    reclosers (Exhaustive Search)
36 % Analysis with reclosers in P1, in P2 and in P3
37 Tasa_Fallas_P1_P2_P3_Usuario1=Tasa_Fallas_Cargas(1)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
38 Tasa_Fallas_P1_P2_P3_Usuario2=Tasa_Fallas_Cargas(2)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(5:12));
39 Tasa_Fallas_P1_P2_P3_Usuario3=Tasa_Fallas_Cargas(3)+sum(

```

```
Tasa_Fallas_Troncales);
40 Tasa_Fallas_P1_P2_P3_Usuario4=Tasa_Fallas_Cargas(4)+sum(
    Tasa_Fallas_Troncales);
41 Tasa_Fallas_P1_P2_P3_Usuario5=Tasa_Fallas_Cargas(5)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
42 Tasa_Fallas_P1_P2_P3_Usuario6=Tasa_Fallas_Cargas(6)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
43 Tasa_Fallas_P1_P2_P3_Usuario7=Tasa_Fallas_Cargas(7)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
44 Tasa_Fallas_P1_P2_P3_Usuario8=Tasa_Fallas_Cargas(8)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
45 Tasa_Fallas_P1_P2_P3_Usuario9=Tasa_Fallas_Cargas(9)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
46 Tasa_Fallas_P1_P2_P3_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(5:12));
47 Tasa_Fallas_P1_P2_P3_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(5:12));
48 Tasa_Fallas_P1_P2_P3_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(5:12));
49 Tasa_Fallas_P1_P2_P3_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales);
50 Tasa_Fallas_P1_P2_P3_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales);
51
52 Tasa_Fallas_P1_P2_P3_Usuarios=[Tasa_Fallas_P1_P2_P3_Usuario1
    Tasa_Fallas_P1_P2_P3_Usuario2 Tasa_Fallas_P1_P2_P3_Usuario3
    Tasa_Fallas_P1_P2_P3_Usuario4 Tasa_Fallas_P1_P2_P3_Usuario5
    Tasa_Fallas_P1_P2_P3_Usuario6 Tasa_Fallas_P1_P2_P3_Usuario7
    Tasa_Fallas_P1_P2_P3_Usuario8 Tasa_Fallas_P1_P2_P3_Usuario9
    Tasa_Fallas_P1_P2_P3_Usuario10 Tasa_Fallas_P1_P2_P3_Usuario11
    Tasa_Fallas_P1_P2_P3_Usuario12 Tasa_Fallas_P1_P2_P3_Usuario13
    Tasa_Fallas_P1_P2_P3_Usuario14];
53
54 Duracion_Reparacion_P1_P2_P3_Usuario1=U_Cargas(1)+U_Troncales(1)+sum
    (U_Troncales(5:9));
55 Duracion_Reparacion_P1_P2_P3_Usuario2=U_Cargas(2)+sum(U_Troncales
    (1:2))+sum(U_Troncales(5:12));
56 Duracion_Reparacion_P1_P2_P3_Usuario3=U_Cargas(3)+sum(U_Troncales);
57 Duracion_Reparacion_P1_P2_P3_Usuario4=U_Cargas(4)+sum(U_Troncales);
58 Duracion_Reparacion_P1_P2_P3_Usuario5=U_Cargas(5)+U_Troncales(1)+sum
    (U_Troncales(5:9));
59 Duracion_Reparacion_P1_P2_P3_Usuario6=U_Cargas(6)+U_Troncales(1)+sum
    (U_Troncales(5:9));
60 Duracion_Reparacion_P1_P2_P3_Usuario7=U_Cargas(7)+U_Troncales(1)+sum
    (U_Troncales(5:9));
61 Duracion_Reparacion_P1_P2_P3_Usuario8=U_Cargas(8)+U_Troncales(1)+sum
    (U_Troncales(5:9));
62 Duracion_Reparacion_P1_P2_P3_Usuario9=U_Cargas(9)+U_Troncales(1)+sum
    (U_Troncales(5:9));
63 Duracion_Reparacion_P1_P2_P3_Usuario10=U_Cargas(10)+sum(U_Troncales
    (1:2))+sum(U_Troncales(5:12));
64 Duracion_Reparacion_P1_P2_P3_Usuario11=U_Cargas(11)+sum(U_Troncales
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        (1:2))+sum(U_Troncales(5:12));
65 Duracion_Reparacion_P1_P2_P3_Usuario12=U_Cargas(12)+sum(U_Troncales
    (1:2))+sum(U_Troncales(5:12));
66 Duracion_Reparacion_P1_P2_P3_Usuario13=U_Cargas(13)+sum(U_Troncales)
    ;
67 Duracion_Reparacion_P1_P2_P3_Usuario14=U_Cargas(14)+sum(U_Troncales)
    ;
68
69 Duracion_Reparacion_P1_P2_P3_Usuarios=[
    Duracion_Reparacion_P1_P2_P3_Usuario1
    Duracion_Reparacion_P1_P2_P3_Usuario2
    Duracion_Reparacion_P1_P2_P3_Usuario3
    Duracion_Reparacion_P1_P2_P3_Usuario4
    Duracion_Reparacion_P1_P2_P3_Usuario5
    Duracion_Reparacion_P1_P2_P3_Usuario6
    Duracion_Reparacion_P1_P2_P3_Usuario7
    Duracion_Reparacion_P1_P2_P3_Usuario8
    Duracion_Reparacion_P1_P2_P3_Usuario9
    Duracion_Reparacion_P1_P2_P3_Usuario10
    Duracion_Reparacion_P1_P2_P3_Usuario11
    Duracion_Reparacion_P1_P2_P3_Usuario12
    Duracion_Reparacion_P1_P2_P3_Usuario13
    Duracion_Reparacion_P1_P2_P3_Usuario14];
70
71 SAIFI_P1_P2_P3 = (Tasa_Fallas_P1_P2_P3_Usuario1*Cantidad_Usuarios(1)
    +Tasa_Fallas_P1_P2_P3_Usuario2*Cantidad_Usuarios(2)+
    Tasa_Fallas_P1_P2_P3_Usuario3*Cantidad_Usuarios(3)+
    Tasa_Fallas_P1_P2_P3_Usuario4*Cantidad_Usuarios(4)+
    Tasa_Fallas_P1_P2_P3_Usuario5*Cantidad_Usuarios(5)+
    Tasa_Fallas_P1_P2_P3_Usuario6*Cantidad_Usuarios(6)+
    Tasa_Fallas_P1_P2_P3_Usuario7*Cantidad_Usuarios(7)+
    Tasa_Fallas_P1_P2_P3_Usuario8*Cantidad_Usuarios(8)+
    Tasa_Fallas_P1_P2_P3_Usuario9*Cantidad_Usuarios(9)+
    Tasa_Fallas_P1_P2_P3_Usuario10*Cantidad_Usuarios(10)+
    Tasa_Fallas_P1_P2_P3_Usuario11*Cantidad_Usuarios(11)+
    Tasa_Fallas_P1_P2_P3_Usuario12*Cantidad_Usuarios(12)+
    Tasa_Fallas_P1_P2_P3_Usuario13*Cantidad_Usuarios(13)+
    Tasa_Fallas_P1_P2_P3_Usuario14*Cantidad_Usuarios(14))/
    Total_Consumidores; % Number of average failures per year per
    user
72 SAIDI_P1_P2_P3 = (Duracion_Reparacion_P1_P2_P3_Usuario1*
    Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P2_P3_Usuario2*
    Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P2_P3_Usuario3*
    Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P2_P3_Usuario4*
    Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P2_P3_Usuario5*
    Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P2_P3_Usuario6*
    Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P2_P3_Usuario7*
    Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P2_P3_Usuario8*
    Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P2_P3_Usuario9*
    Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P2_P3_Usuario10*
    Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P2_P3_Usuario11*
    Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P2_P3_Usuario12*

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Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P2_P3_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P2_P3_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores; % Average repair time
per year per user
73 CAIDI_P1_P2_P3 = SAIDI_P1_P2_P3 / SAIFI_P1_P2_P3; % Average Duration
of an Interruption
74 AENS_P1_P2_P3 = (Duracion_Reparacion_P1_P2_P3_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P2_P3_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P2_P3_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P2_P3_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P2_P3_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P2_P3_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P2_P3_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P2_P3_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P2_P3_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P2_P3_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P2_P3_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P2_P3_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P2_P3_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P2_P3_Usuario14*
Demanda_Usuario(14))/Total_Consumidores; % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
75
76
77 % Analysis with reclosers in P1, in P2 and in P5
78 Tasa_Fallas_P1_P2_P5_Usuario1=Tasa_Fallas_Cargas(1)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(8:9));
79 Tasa_Fallas_P1_P2_P5_Usuario2=Tasa_Fallas_Cargas(2)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
80 Tasa_Fallas_P1_P2_P5_Usuario3=Tasa_Fallas_Cargas(3)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
81 Tasa_Fallas_P1_P2_P5_Usuario4=Tasa_Fallas_Cargas(4)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
82 Tasa_Fallas_P1_P2_P5_Usuario5=Tasa_Fallas_Cargas(5)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
83 Tasa_Fallas_P1_P2_P5_Usuario6=Tasa_Fallas_Cargas(6)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
84 Tasa_Fallas_P1_P2_P5_Usuario7=Tasa_Fallas_Cargas(7)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
85 Tasa_Fallas_P1_P2_P5_Usuario8=Tasa_Fallas_Cargas(8)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(8:9));
86 Tasa_Fallas_P1_P2_P5_Usuario9=Tasa_Fallas_Cargas(9)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(8:9));
87 Tasa_Fallas_P1_P2_P5_Usuario10=Tasa_Fallas_Cargas(10)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
88 Tasa_Fallas_P1_P2_P5_Usuario11=Tasa_Fallas_Cargas(11)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
89 Tasa_Fallas_P1_P2_P5_Usuario12=Tasa_Fallas_Cargas(12)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
90 Tasa_Fallas_P1_P2_P5_Usuario13=Tasa_Fallas_Cargas(13)+sum(
Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
91 Tasa_Fallas_P1_P2_P5_Usuario14=Tasa_Fallas_Cargas(14)+sum(

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Tasa_Fallas_Troncales(1:4))+sum(Tasa_Fallas_Troncales(8:14));
92
93 Tasa_Fallas_P1_P2_P5_Usuarios=[Tasa_Fallas_P1_P2_P5_Usuario1
    Tasa_Fallas_P1_P2_P5_Usuario2 Tasa_Fallas_P1_P2_P5_Usuario3
    Tasa_Fallas_P1_P2_P5_Usuario4 Tasa_Fallas_P1_P2_P5_Usuario5
    Tasa_Fallas_P1_P2_P5_Usuario6 Tasa_Fallas_P1_P2_P5_Usuario7
    Tasa_Fallas_P1_P2_P5_Usuario8 Tasa_Fallas_P1_P2_P5_Usuario9
    Tasa_Fallas_P1_P2_P5_Usuario10 Tasa_Fallas_P1_P2_P5_Usuario11
    Tasa_Fallas_P1_P2_P5_Usuario12 Tasa_Fallas_P1_P2_P5_Usuario13
    Tasa_Fallas_P1_P2_P5_Usuario14];
94
95 Duracion_Reparacion_P1_P2_P5_Usuario1=U_Cargas(1)+U_Troncales(1)+sum
    (U_Troncales(8:9));
96 Duracion_Reparacion_P1_P2_P5_Usuario2=U_Cargas(2)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
97 Duracion_Reparacion_P1_P2_P5_Usuario3=U_Cargas(3)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
98 Duracion_Reparacion_P1_P2_P5_Usuario4=U_Cargas(4)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
99 Duracion_Reparacion_P1_P2_P5_Usuario5=U_Cargas(5)+U_Troncales(1)+sum
    (U_Troncales(5:9));
100 Duracion_Reparacion_P1_P2_P5_Usuario6=U_Cargas(6)+U_Troncales(1)+sum
    (U_Troncales(5:9));
101 Duracion_Reparacion_P1_P2_P5_Usuario7=U_Cargas(7)+U_Troncales(1)+sum
    (U_Troncales(5:9));
102 Duracion_Reparacion_P1_P2_P5_Usuario8=U_Cargas(8)+U_Troncales(1)+sum
    (U_Troncales(8:9));
103 Duracion_Reparacion_P1_P2_P5_Usuario9=U_Cargas(9)+U_Troncales(1)+sum
    (U_Troncales(8:9));
104 Duracion_Reparacion_P1_P2_P5_Usuario10=U_Cargas(10)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
105 Duracion_Reparacion_P1_P2_P5_Usuario11=U_Cargas(11)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
106 Duracion_Reparacion_P1_P2_P5_Usuario12=U_Cargas(12)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
107 Duracion_Reparacion_P1_P2_P5_Usuario13=U_Cargas(13)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
108 Duracion_Reparacion_P1_P2_P5_Usuario14=U_Cargas(14)+sum(U_Troncales
    (1:4))+sum(U_Troncales(8:14));
109
110 Duracion_Reparacion_P1_P2_P5_Usuarios=[
    Duracion_Reparacion_P1_P2_P5_Usuario1
    Duracion_Reparacion_P1_P2_P5_Usuario2
    Duracion_Reparacion_P1_P2_P5_Usuario3
    Duracion_Reparacion_P1_P2_P5_Usuario4
    Duracion_Reparacion_P1_P2_P5_Usuario5
    Duracion_Reparacion_P1_P2_P5_Usuario6
    Duracion_Reparacion_P1_P2_P5_Usuario7
    Duracion_Reparacion_P1_P2_P5_Usuario8
    Duracion_Reparacion_P1_P2_P5_Usuario9
    Duracion_Reparacion_P1_P2_P5_Usuario10
    Duracion_Reparacion_P1_P2_P5_Usuario11
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Duracion_Reparacion_P1_P2_P5_Usuario12
Duracion_Reparacion_P1_P2_P5_Usuario13
Duracion_Reparacion_P1_P2_P5_Usuario14];
111
112 SAIFI_P1_P2_P5 = (Tasa_Fallas_P1_P2_P5_Usuario1*Cantidad_Usuarios(1)
+Tasa_Fallas_P1_P2_P5_Usuario2*Cantidad_Usuarios(2)+
Tasa_Fallas_P1_P2_P5_Usuario3*Cantidad_Usuarios(3)+
Tasa_Fallas_P1_P2_P5_Usuario4*Cantidad_Usuarios(4)+
Tasa_Fallas_P1_P2_P5_Usuario5*Cantidad_Usuarios(5)+
Tasa_Fallas_P1_P2_P5_Usuario6*Cantidad_Usuarios(6)+
Tasa_Fallas_P1_P2_P5_Usuario7*Cantidad_Usuarios(7)+
Tasa_Fallas_P1_P2_P5_Usuario8*Cantidad_Usuarios(8)+
Tasa_Fallas_P1_P2_P5_Usuario9*Cantidad_Usuarios(9)+
Tasa_Fallas_P1_P2_P5_Usuario10*Cantidad_Usuarios(10)+
Tasa_Fallas_P1_P2_P5_Usuario11*Cantidad_Usuarios(11)+
Tasa_Fallas_P1_P2_P5_Usuario12*Cantidad_Usuarios(12)+
Tasa_Fallas_P1_P2_P5_Usuario13*Cantidad_Usuarios(13)+
Tasa_Fallas_P1_P2_P5_Usuario14*Cantidad_Usuarios(14))/
Total_Consumidores; % Number of average failures per year per
user
113 SAIDI_P1_P2_P5 = (Duracion_Reparacion_P1_P2_P5_Usuario1*
Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P2_P5_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P2_P5_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P2_P5_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P2_P5_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P2_P5_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P2_P5_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P2_P5_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P2_P5_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P2_P5_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P2_P5_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P2_P5_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P2_P5_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P2_P5_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores; % Average repair time
per year per user
114 CAIDI_P1_P2_P5 = SAIDI_P1_P2_P5 / SAIFI_P1_P2_P5; % Average Duration
of an Interruption
115 AENS_P1_P2_P5 = (Duracion_Reparacion_P1_P2_P5_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P2_P5_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P2_P5_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P2_P5_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P2_P5_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P2_P5_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P2_P5_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P2_P5_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P2_P5_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P2_P5_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P2_P5_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P2_P5_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P2_P5_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P2_P5_Usuario14*
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    Demanda_Usuario(14))/Total_Consumidores; % Average energy NOT
    supplied per year per user (kWh Not Supplied / User)
116
117 % Analysis with reclosers in P1, in P2 and in P8
118 Tasa_Fallas_P1_P2_P8_Usuario1=Tasa_Fallas_Cargas(1)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:7));
119 Tasa_Fallas_P1_P2_P8_Usuario2=Tasa_Fallas_Cargas(2)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
120 Tasa_Fallas_P1_P2_P8_Usuario3=Tasa_Fallas_Cargas(3)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
121 Tasa_Fallas_P1_P2_P8_Usuario4=Tasa_Fallas_Cargas(4)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
122 Tasa_Fallas_P1_P2_P8_Usuario5=Tasa_Fallas_Cargas(5)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:7));
123 Tasa_Fallas_P1_P2_P8_Usuario6=Tasa_Fallas_Cargas(6)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:7));
124 Tasa_Fallas_P1_P2_P8_Usuario7=Tasa_Fallas_Cargas(7)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:7));
125 Tasa_Fallas_P1_P2_P8_Usuario8=Tasa_Fallas_Cargas(8)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(8:9));
126 Tasa_Fallas_P1_P2_P8_Usuario9=Tasa_Fallas_Cargas(9)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(8:9));
127 Tasa_Fallas_P1_P2_P8_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
128 Tasa_Fallas_P1_P2_P8_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
129 Tasa_Fallas_P1_P2_P8_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
130 Tasa_Fallas_P1_P2_P8_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
131 Tasa_Fallas_P1_P2_P8_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales(1:7))+sum(Tasa_Fallas_Troncales(10:14));
132
133 Tasa_Fallas_P1_P2_P8_Usuarios=[Tasa_Fallas_P1_P2_P8_Usuario1
    Tasa_Fallas_P1_P2_P8_Usuario2 Tasa_Fallas_P1_P2_P8_Usuario3
    Tasa_Fallas_P1_P2_P8_Usuario4 Tasa_Fallas_P1_P2_P8_Usuario5
    Tasa_Fallas_P1_P2_P8_Usuario6 Tasa_Fallas_P1_P2_P8_Usuario7
    Tasa_Fallas_P1_P2_P8_Usuario8 Tasa_Fallas_P1_P2_P8_Usuario9
    Tasa_Fallas_P1_P2_P8_Usuario10 Tasa_Fallas_P1_P2_P8_Usuario11
    Tasa_Fallas_P1_P2_P8_Usuario12 Tasa_Fallas_P1_P2_P8_Usuario13
    Tasa_Fallas_P1_P2_P8_Usuario14];
134
135 Duracion_Reparacion_P1_P2_P8_Usuario1=U_Cargas(1)+U_Troncales(1)+sum
    (U_Troncales(5:7));
136 Duracion_Reparacion_P1_P2_P8_Usuario2=U_Cargas(2)+sum(U_Troncales
    (1:7))+sum(U_Troncales(10:14));
137 Duracion_Reparacion_P1_P2_P8_Usuario3=U_Cargas(3)+sum(U_Troncales
    (1:7))+sum(U_Troncales(10:14));
138 Duracion_Reparacion_P1_P2_P8_Usuario4=U_Cargas(4)+sum(U_Troncales
    (1:7))+sum(U_Troncales(10:14));
139 Duracion_Reparacion_P1_P2_P8_Usuario5=U_Cargas(5)+U_Troncales(1)+sum
    (U_Troncales(5:7));

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140 Duracion_Reparacion_P1_P2_P8_Usuario6=U_Cargas(6)+U_Troncales(1)+sum
      (U_Troncales(5:7));
141 Duracion_Reparacion_P1_P2_P8_Usuario7=U_Cargas(7)+U_Troncales(1)+sum
      (U_Troncales(5:7));
142 Duracion_Reparacion_P1_P2_P8_Usuario8=U_Cargas(8)+U_Troncales(1)+sum
      (U_Troncales(8:9));
143 Duracion_Reparacion_P1_P2_P8_Usuario9=U_Cargas(9)+U_Troncales(1)+sum
      (U_Troncales(8:9));
144 Duracion_Reparacion_P1_P2_P8_Usuario10=U_Cargas(10)+sum(U_Troncales
      (1:7))+sum(U_Troncales(10:14));
145 Duracion_Reparacion_P1_P2_P8_Usuario11=U_Cargas(11)+sum(U_Troncales
      (1:7))+sum(U_Troncales(10:14));
146 Duracion_Reparacion_P1_P2_P8_Usuario12=U_Cargas(12)+sum(U_Troncales
      (1:7))+sum(U_Troncales(10:14));
147 Duracion_Reparacion_P1_P2_P8_Usuario13=U_Cargas(13)+sum(U_Troncales
      (1:7))+sum(U_Troncales(10:14));
148 Duracion_Reparacion_P1_P2_P8_Usuario14=U_Cargas(14)+sum(U_Troncales
      (1:7))+sum(U_Troncales(10:14));
149
150 Duracion_Reparacion_P1_P2_P8_Usuarios=[
      Duracion_Reparacion_P1_P2_P8_Usuario1
      Duracion_Reparacion_P1_P2_P8_Usuario2
      Duracion_Reparacion_P1_P2_P8_Usuario3
      Duracion_Reparacion_P1_P2_P8_Usuario4
      Duracion_Reparacion_P1_P2_P8_Usuario5
      Duracion_Reparacion_P1_P2_P8_Usuario6
      Duracion_Reparacion_P1_P2_P8_Usuario7
      Duracion_Reparacion_P1_P2_P8_Usuario8
      Duracion_Reparacion_P1_P2_P8_Usuario9
      Duracion_Reparacion_P1_P2_P8_Usuario10
      Duracion_Reparacion_P1_P2_P8_Usuario11
      Duracion_Reparacion_P1_P2_P8_Usuario12
      Duracion_Reparacion_P1_P2_P8_Usuario13
      Duracion_Reparacion_P1_P2_P8_Usuario14];
151
152 SAIFI_P1_P2_P8 = (Tasa_Fallas_P1_P2_P8_Usuario1*Cantidad_Usuarios(1)
      +Tasa_Fallas_P1_P2_P8_Usuario2*Cantidad_Usuarios(2)+
      Tasa_Fallas_P1_P2_P8_Usuario3*Cantidad_Usuarios(3)+
      Tasa_Fallas_P1_P2_P8_Usuario4*Cantidad_Usuarios(4)+
      Tasa_Fallas_P1_P2_P8_Usuario5*Cantidad_Usuarios(5)+
      Tasa_Fallas_P1_P2_P8_Usuario6*Cantidad_Usuarios(6)+
      Tasa_Fallas_P1_P2_P8_Usuario7*Cantidad_Usuarios(7)+
      Tasa_Fallas_P1_P2_P8_Usuario8*Cantidad_Usuarios(8)+
      Tasa_Fallas_P1_P2_P8_Usuario9*Cantidad_Usuarios(9)+
      Tasa_Fallas_P1_P2_P8_Usuario10*Cantidad_Usuarios(10)+
      Tasa_Fallas_P1_P2_P8_Usuario11*Cantidad_Usuarios(11)+
      Tasa_Fallas_P1_P2_P8_Usuario12*Cantidad_Usuarios(12)+
      Tasa_Fallas_P1_P2_P8_Usuario13*Cantidad_Usuarios(13)+
      Tasa_Fallas_P1_P2_P8_Usuario14*Cantidad_Usuarios(14))/
      Total_Consumidores; % Number of average failures per year per
      user
153 SAIDI_P1_P2_P8 = (Duracion_Reparacion_P1_P2_P8_Usuario1*
```



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Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P2_P8_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P2_P8_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P2_P8_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P2_P8_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P2_P8_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P2_P8_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P2_P8_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P2_P8_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P2_P8_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P2_P8_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P2_P8_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P2_P8_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P2_P8_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores; % Average repair time
per year per user
154 CAIDI_P1_P2_P8 = SAIDI_P1_P2_P8 / SAIFI_P1_P2_P8; % Average Duration
of an Interruption
155 AENS_P1_P2_P8 = (Duracion_Reparacion_P1_P2_P8_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P2_P8_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P2_P8_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P2_P8_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P2_P8_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P2_P8_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P2_P8_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P2_P8_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P2_P8_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P2_P8_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P2_P8_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P2_P8_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P2_P8_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P2_P8_Usuario14*
Demanda_Usuario(14))/Total_Consumidores; % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
156
157
158 % Analysis with reclosers in P1, in P2 and in P10
159 Tasa_Fallas_P1_P2_P10_Usuario1=Tasa_Fallas_Cargas(1)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
160 Tasa_Fallas_P1_P2_P10_Usuario2=Tasa_Fallas_Cargas(2)+sum(
Tasa_Fallas_Troncales(1:9))+sum(Tasa_Fallas_Troncales(13:14));
161 Tasa_Fallas_P1_P2_P10_Usuario3=Tasa_Fallas_Cargas(3)+sum(
Tasa_Fallas_Troncales(1:9))+sum(Tasa_Fallas_Troncales(13:14));
162 Tasa_Fallas_P1_P2_P10_Usuario4=Tasa_Fallas_Cargas(4)+sum(
Tasa_Fallas_Troncales(1:9))+sum(Tasa_Fallas_Troncales(13:14));
163 Tasa_Fallas_P1_P2_P10_Usuario5=Tasa_Fallas_Cargas(5)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
164 Tasa_Fallas_P1_P2_P10_Usuario6=Tasa_Fallas_Cargas(6)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
165 Tasa_Fallas_P1_P2_P10_Usuario7=Tasa_Fallas_Cargas(7)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
166 Tasa_Fallas_P1_P2_P10_Usuario8=Tasa_Fallas_Cargas(8)+
Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));

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167 Tasa_Fallas_P1_P2_P10_Usuario9=Tasa_Fallas_Cargas(9)+
    Tasa_Fallas_Troncales(1)+sum(Tasa_Fallas_Troncales(5:9));
168 Tasa_Fallas_P1_P2_P10_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales);
169 Tasa_Fallas_P1_P2_P10_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales);
170 Tasa_Fallas_P1_P2_P10_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales);
171 Tasa_Fallas_P1_P2_P10_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales(1:9))+sum(Tasa_Fallas_Troncales(13:14));
172 Tasa_Fallas_P1_P2_P10_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales(1:9))+sum(Tasa_Fallas_Troncales(13:14));
173
174 Tasa_Fallas_P1_P2_P10_Usuarios=[Tasa_Fallas_P1_P2_P10_Usuario1
    Tasa_Fallas_P1_P2_P10_Usuario2 Tasa_Fallas_P1_P2_P10_Usuario3
    Tasa_Fallas_P1_P2_P10_Usuario4 Tasa_Fallas_P1_P2_P10_Usuario5
    Tasa_Fallas_P1_P2_P10_Usuario6 Tasa_Fallas_P1_P2_P10_Usuario7
    Tasa_Fallas_P1_P2_P10_Usuario8 Tasa_Fallas_P1_P2_P10_Usuario9
    Tasa_Fallas_P1_P2_P10_Usuario10 Tasa_Fallas_P1_P2_P10_Usuario11
    Tasa_Fallas_P1_P2_P10_Usuario12 Tasa_Fallas_P1_P2_P10_Usuario13
    Tasa_Fallas_P1_P2_P10_Usuario14];
175
176 Duracion_Reparacion_P1_P2_P10_Usuario1=U_Cargas(1)+U_Troncales(1)+
    sum(U_Troncales(5:9));
177 Duracion_Reparacion_P1_P2_P10_Usuario2=U_Cargas(2)+sum(U_Troncales
    (1:9))+sum(U_Troncales(13:14));
178 Duracion_Reparacion_P1_P2_P10_Usuario3=U_Cargas(3)+sum(U_Troncales
    (1:9))+sum(U_Troncales(13:14));
179 Duracion_Reparacion_P1_P2_P10_Usuario4=U_Cargas(4)+sum(U_Troncales
    (1:9))+sum(U_Troncales(13:14));
180 Duracion_Reparacion_P1_P2_P10_Usuario5=U_Cargas(5)+U_Troncales(1)+
    sum(U_Troncales(5:9));
181 Duracion_Reparacion_P1_P2_P10_Usuario6=U_Cargas(6)+U_Troncales(1)+
    sum(U_Troncales(5:9));
182 Duracion_Reparacion_P1_P2_P10_Usuario7=U_Cargas(7)+U_Troncales(1)+
    sum(U_Troncales(5:9));
183 Duracion_Reparacion_P1_P2_P10_Usuario8=U_Cargas(8)+U_Troncales(1)+
    sum(U_Troncales(5:9));
184 Duracion_Reparacion_P1_P2_P10_Usuario9=U_Cargas(9)+U_Troncales(1)+
    sum(U_Troncales(5:9));
185 Duracion_Reparacion_P1_P2_P10_Usuario10=U_Cargas(10)+sum(U_Troncales
    );
186 Duracion_Reparacion_P1_P2_P10_Usuario11=U_Cargas(11)+sum(U_Troncales
    );
187 Duracion_Reparacion_P1_P2_P10_Usuario12=U_Cargas(12)+sum(U_Troncales
    );
188 Duracion_Reparacion_P1_P2_P10_Usuario13=U_Cargas(13)+sum(U_Troncales
    (1:9))+sum(U_Troncales(13:14));
189 Duracion_Reparacion_P1_P2_P10_Usuario14=U_Cargas(14)+sum(U_Troncales
    (1:9))+sum(U_Troncales(13:14));
190
191 Duracion_Reparacion_P1_P2_P10_Usuarios=[
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Duracion_Reparacion_P1_P2_P10_Usuario1
Duracion_Reparacion_P1_P2_P10_Usuario2
Duracion_Reparacion_P1_P2_P10_Usuario3
Duracion_Reparacion_P1_P2_P10_Usuario4
Duracion_Reparacion_P1_P2_P10_Usuario5
Duracion_Reparacion_P1_P2_P10_Usuario6
Duracion_Reparacion_P1_P2_P10_Usuario7
Duracion_Reparacion_P1_P2_P10_Usuario8
Duracion_Reparacion_P1_P2_P10_Usuario9
Duracion_Reparacion_P1_P2_P10_Usuario10
Duracion_Reparacion_P1_P2_P10_Usuario11
Duracion_Reparacion_P1_P2_P10_Usuario12
Duracion_Reparacion_P1_P2_P10_Usuario13
Duracion_Reparacion_P1_P2_P10_Usuario14];
192
193 SAIFI_P1_P2_P10 = (Tasa_Fallas_P1_P2_P10_Usuario1*Cantidad_Usuarios
(1)+Tasa_Fallas_P1_P2_P10_Usuario2*Cantidad_Usuarios(2)+
Tasa_Fallas_P1_P2_P10_Usuario3*Cantidad_Usuarios(3)+
Tasa_Fallas_P1_P2_P10_Usuario4*Cantidad_Usuarios(4)+
Tasa_Fallas_P1_P2_P10_Usuario5*Cantidad_Usuarios(5)+
Tasa_Fallas_P1_P2_P10_Usuario6*Cantidad_Usuarios(6)+
Tasa_Fallas_P1_P2_P10_Usuario7*Cantidad_Usuarios(7)+
Tasa_Fallas_P1_P2_P10_Usuario8*Cantidad_Usuarios(8)+
Tasa_Fallas_P1_P2_P10_Usuario9*Cantidad_Usuarios(9)+
Tasa_Fallas_P1_P2_P10_Usuario10*Cantidad_Usuarios(10)+
Tasa_Fallas_P1_P2_P10_Usuario11*Cantidad_Usuarios(11)+
Tasa_Fallas_P1_P2_P10_Usuario12*Cantidad_Usuarios(12)+
Tasa_Fallas_P1_P2_P10_Usuario13*Cantidad_Usuarios(13)+
Tasa_Fallas_P1_P2_P10_Usuario14*Cantidad_Usuarios(14))/
Total_Consumidores; % Number of average failures per year per
user
194 SAIDI_P1_P2_P10 = (Duracion_Reparacion_P1_P2_P10_Usuario1*
Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P2_P10_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P2_P10_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P2_P10_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P2_P10_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P2_P10_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P2_P10_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P2_P10_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P2_P10_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P2_P10_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P2_P10_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P2_P10_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P2_P10_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P2_P10_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores; % Average repair time
per year per user
195 CAIDI_P1_P2_P10 = SAIDI_P1_P2_P10 / SAIFI_P1_P2_P10; % Average
Duration of an Interruption
196 AENS_P1_P2_P10 = (Duracion_Reparacion_P1_P2_P10_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P2_P10_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P2_P10_Usuario3*

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Demanda_Usuario(3)+Duracion_Reparacion_P1_P2_P10_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P2_P10_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P2_P10_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P2_P10_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P2_P10_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P2_P10_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P2_P10_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P2_P10_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P2_P10_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P2_P10_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P2_P10_Usuario14*
Demanda_Usuario(14))/Total_Consumidores; % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
197
198 % Analysis with reclosers in P1, in P3 and in P5
199 Tasa_Fallas_P1_P3_P5_Usuario1=Tasa_Fallas_Cargas(1)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
200 Tasa_Fallas_P1_P3_P5_Usuario2=Tasa_Fallas_Cargas(2)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
201 Tasa_Fallas_P1_P3_P5_Usuario3=Tasa_Fallas_Cargas(3)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
202 Tasa_Fallas_P1_P3_P5_Usuario4=Tasa_Fallas_Cargas(4)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
203 Tasa_Fallas_P1_P3_P5_Usuario5=Tasa_Fallas_Cargas(5)+sum(
    Tasa_Fallas_Troncales)-(Tasa_Fallas_Troncales(4))-sum(
    Tasa_Fallas_Troncales(13:14));
204 Tasa_Fallas_P1_P3_P5_Usuario6=Tasa_Fallas_Cargas(6)+sum(
    Tasa_Fallas_Troncales)-(Tasa_Fallas_Troncales(4))-sum(
    Tasa_Fallas_Troncales(13:14));
205 Tasa_Fallas_P1_P3_P5_Usuario7=Tasa_Fallas_Cargas(7)+sum(
    Tasa_Fallas_Troncales)-(Tasa_Fallas_Troncales(4))-sum(
    Tasa_Fallas_Troncales(13:14));
206 Tasa_Fallas_P1_P3_P5_Usuario8=Tasa_Fallas_Cargas(8)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
207 Tasa_Fallas_P1_P3_P5_Usuario9=Tasa_Fallas_Cargas(9)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
208 Tasa_Fallas_P1_P3_P5_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
209 Tasa_Fallas_P1_P3_P5_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
210 Tasa_Fallas_P1_P3_P5_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales(1:2))+sum(Tasa_Fallas_Troncales(8:9))+sum(
    Tasa_Fallas_Troncales(10:12));
211 Tasa_Fallas_P1_P3_P5_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
212 Tasa_Fallas_P1_P3_P5_Usuario14=Tasa_Fallas_Cargas(14)+sum(

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Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
213
214 Tasa_Fallas_P1_P3_P5_Usuarios=[Tasa_Fallas_P1_P3_P5_Usuario1
    Tasa_Fallas_P1_P3_P5_Usuario2 Tasa_Fallas_P1_P3_P5_Usuario3
    Tasa_Fallas_P1_P3_P5_Usuario4 Tasa_Fallas_P1_P3_P5_Usuario5
    Tasa_Fallas_P1_P3_P5_Usuario6 Tasa_Fallas_P1_P3_P5_Usuario7
    Tasa_Fallas_P1_P3_P5_Usuario8 Tasa_Fallas_P1_P3_P5_Usuario9
    Tasa_Fallas_P1_P3_P5_Usuario10 Tasa_Fallas_P1_P3_P5_Usuario11
    Tasa_Fallas_P1_P3_P5_Usuario12 Tasa_Fallas_P1_P3_P5_Usuario13
    Tasa_Fallas_P1_P3_P5_Usuario14];
215
216 Duracion_Reparacion_P1_P3_P5_Usuario1=U_Cargas(1)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
217 Duracion_Reparacion_P1_P3_P5_Usuario2=U_Cargas(2)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
218 Duracion_Reparacion_P1_P3_P5_Usuario3=U_Cargas(3)+sum(U_Troncales)-
    sum(U_Troncales(5:7));
219 Duracion_Reparacion_P1_P3_P5_Usuario4=U_Cargas(4)+sum(U_Troncales)-
    sum(U_Troncales(5:7));
220 Duracion_Reparacion_P1_P3_P5_Usuario5=U_Cargas(5)+sum(U_Troncales)-(
    U_Troncales(4))-sum(U_Troncales(13:14));
221 Duracion_Reparacion_P1_P3_P5_Usuario6=U_Cargas(6)+sum(U_Troncales)-(
    U_Troncales(4))-sum(U_Troncales(13:14));
222 Duracion_Reparacion_P1_P3_P5_Usuario7=U_Cargas(7)+sum(U_Troncales)-(
    U_Troncales(4))-sum(U_Troncales(13:14));
223 Duracion_Reparacion_P1_P3_P5_Usuario8=U_Cargas(8)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
224 Duracion_Reparacion_P1_P3_P5_Usuario9=U_Cargas(9)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
225 Duracion_Reparacion_P1_P3_P5_Usuario10=U_Cargas(10)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
226 Duracion_Reparacion_P1_P3_P5_Usuario11=U_Cargas(11)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
227 Duracion_Reparacion_P1_P3_P5_Usuario12=U_Cargas(12)+sum(U_Troncales
    (1:2))+sum(U_Troncales(8:9))+sum(U_Troncales(10:12));
228 Duracion_Reparacion_P1_P3_P5_Usuario13=U_Cargas(13)+sum(U_Troncales)
    -sum(U_Troncales(5:7));
229 Duracion_Reparacion_P1_P3_P5_Usuario14=U_Cargas(14)+sum(U_Troncales)
    -sum(U_Troncales(5:7));
230
231 Duracion_Reparacion_P1_P3_P5_Usuarios=[
    Duracion_Reparacion_P1_P3_P5_Usuario1
    Duracion_Reparacion_P1_P3_P5_Usuario2
    Duracion_Reparacion_P1_P3_P5_Usuario3
    Duracion_Reparacion_P1_P3_P5_Usuario4
    Duracion_Reparacion_P1_P3_P5_Usuario5
    Duracion_Reparacion_P1_P3_P5_Usuario6
    Duracion_Reparacion_P1_P3_P5_Usuario7
    Duracion_Reparacion_P1_P3_P5_Usuario8
    Duracion_Reparacion_P1_P3_P5_Usuario9
    Duracion_Reparacion_P1_P3_P5_Usuario10
    Duracion_Reparacion_P1_P3_P5_Usuario11

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Duracion_Reparacion_P1_P3_P5_Usuario12
Duracion_Reparacion_P1_P3_P5_Usuario13
Duracion_Reparacion_P1_P3_P5_Usuario14];
232
233 SAIFI_P1_P3_P5 = (Tasa_Fallas_P1_P3_P5_Usuario1*Cantidad_Usuarios(1)
+Tasa_Fallas_P1_P3_P5_Usuario2*Cantidad_Usuarios(2)+
Tasa_Fallas_P1_P3_P5_Usuario3*Cantidad_Usuarios(3)+
Tasa_Fallas_P1_P3_P5_Usuario4*Cantidad_Usuarios(4)+
Tasa_Fallas_P1_P3_P5_Usuario5*Cantidad_Usuarios(5)+
Tasa_Fallas_P1_P3_P5_Usuario6*Cantidad_Usuarios(6)+
Tasa_Fallas_P1_P3_P5_Usuario7*Cantidad_Usuarios(7)+
Tasa_Fallas_P1_P3_P5_Usuario8*Cantidad_Usuarios(8)+
Tasa_Fallas_P1_P3_P5_Usuario9*Cantidad_Usuarios(9)+
Tasa_Fallas_P1_P3_P5_Usuario10*Cantidad_Usuarios(10)+
Tasa_Fallas_P1_P3_P5_Usuario11*Cantidad_Usuarios(11)+
Tasa_Fallas_P1_P3_P5_Usuario12*Cantidad_Usuarios(12)+
Tasa_Fallas_P1_P3_P5_Usuario13*Cantidad_Usuarios(13)+
Tasa_Fallas_P1_P3_P5_Usuario14*Cantidad_Usuarios(14))/
Total_Consumidores % Number of average failures per year per user
234 SAIDI_P1_P3_P5 = (Duracion_Reparacion_P1_P3_P5_Usuario1*
Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P3_P5_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P3_P5_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P3_P5_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P3_P5_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P3_P5_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P3_P5_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P3_P5_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P3_P5_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P3_P5_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P3_P5_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P3_P5_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P3_P5_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P3_P5_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores % Average repair time
per year per user
235 CAIDI_P1_P3_P5 = SAIDI_P1_P3_P5 / SAIFI_P1_P3_P5 % Average Duration
of an Interruption
236 AENS_P1_P3_P5 = (Duracion_Reparacion_P1_P3_P5_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P3_P5_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P3_P5_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P3_P5_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P3_P5_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P3_P5_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P3_P5_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P3_P5_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P3_P5_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P3_P5_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P3_P5_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P3_P5_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P3_P5_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P3_P5_Usuario14*
Demanda_Usuario(14))/Total_Consumidores % Average energy NOT

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    supplied per year per user (kWh Not Supplied / User)
237
238
239 % Analysis with reclosers in P1, in P3 and in P8
240 Tasa_Fallas_P1_P3_P8_Usuario1=Tasa_Fallas_Cargas(1)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
241 Tasa_Fallas_P1_P3_P8_Usuario2=Tasa_Fallas_Cargas(2)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
242 Tasa_Fallas_P1_P3_P8_Usuario3=Tasa_Fallas_Cargas(3)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
243 Tasa_Fallas_P1_P3_P8_Usuario4=Tasa_Fallas_Cargas(4)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
244 Tasa_Fallas_P1_P3_P8_Usuario5=Tasa_Fallas_Cargas(5)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:9));
245 Tasa_Fallas_P1_P3_P8_Usuario6=Tasa_Fallas_Cargas(6)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:9));
246 Tasa_Fallas_P1_P3_P8_Usuario7=Tasa_Fallas_Cargas(7)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:9));
247 Tasa_Fallas_P1_P3_P8_Usuario8=Tasa_Fallas_Cargas(8)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
248 Tasa_Fallas_P1_P3_P8_Usuario9=Tasa_Fallas_Cargas(9)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
249 Tasa_Fallas_P1_P3_P8_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
250 Tasa_Fallas_P1_P3_P8_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
251 Tasa_Fallas_P1_P3_P8_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
252 Tasa_Fallas_P1_P3_P8_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
253 Tasa_Fallas_P1_P3_P8_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
    Tasa_Fallas_Troncales(8:9));
254
255 Tasa_Fallas_P1_P3_P8_Usuarios=[Tasa_Fallas_P1_P3_P8_Usuario1
    Tasa_Fallas_P1_P3_P8_Usuario2 Tasa_Fallas_P1_P3_P8_Usuario3
    Tasa_Fallas_P1_P3_P8_Usuario4 Tasa_Fallas_P1_P3_P8_Usuario5
    Tasa_Fallas_P1_P3_P8_Usuario6 Tasa_Fallas_P1_P3_P8_Usuario7
    Tasa_Fallas_P1_P3_P8_Usuario8 Tasa_Fallas_P1_P3_P8_Usuario9
    Tasa_Fallas_P1_P3_P8_Usuario10 Tasa_Fallas_P1_P3_P8_Usuario11
    Tasa_Fallas_P1_P3_P8_Usuario12 Tasa_Fallas_P1_P3_P8_Usuario13
    Tasa_Fallas_P1_P3_P8_Usuario14];
256
257 Duracion_Reparacion_P1_P3_P8_Usuario1=U_Cargas(1)+sum(U_Troncales)-
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    sum(U_Troncales(5:9));
258 Duracion_Reparacion_P1_P3_P8_Usuario2=U_Cargas(2)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
259 Duracion_Reparacion_P1_P3_P8_Usuario3=U_Cargas(3)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
260 Duracion_Reparacion_P1_P3_P8_Usuario4=U_Cargas(4)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
261 Duracion_Reparacion_P1_P3_P8_Usuario5=U_Cargas(5)+sum(U_Troncales)-
    sum(U_Troncales(8:9));
262 Duracion_Reparacion_P1_P3_P8_Usuario6=U_Cargas(6)+sum(U_Troncales)-
    sum(U_Troncales(8:9));
263 Duracion_Reparacion_P1_P3_P8_Usuario7=U_Cargas(7)+sum(U_Troncales)-
    sum(U_Troncales(8:9));
264 Duracion_Reparacion_P1_P3_P8_Usuario8=U_Cargas(8)+sum(U_Troncales)-
    sum(U_Troncales(5:7));
265 Duracion_Reparacion_P1_P3_P8_Usuario9=U_Cargas(9)+sum(U_Troncales)-
    sum(U_Troncales(5:7));
266 Duracion_Reparacion_P1_P3_P8_Usuario10=U_Cargas(10)+sum(U_Troncales)
    -sum(U_Troncales(8:9));
267 Duracion_Reparacion_P1_P3_P8_Usuario11=U_Cargas(11)+sum(U_Troncales)
    -sum(U_Troncales(8:9));
268 Duracion_Reparacion_P1_P3_P8_Usuario12=U_Cargas(12)+sum(U_Troncales)
    -sum(U_Troncales(8:9));
269 Duracion_Reparacion_P1_P3_P8_Usuario13=U_Cargas(13)+sum(U_Troncales)
    -sum(U_Troncales(8:9));
270 Duracion_Reparacion_P1_P3_P8_Usuario14=U_Cargas(14)+sum(U_Troncales)
    -sum(U_Troncales(8:9));
271
272 Duracion_Reparacion_P1_P3_P8_Usuarios=[
    Duracion_Reparacion_P1_P3_P8_Usuario1
    Duracion_Reparacion_P1_P3_P8_Usuario2
    Duracion_Reparacion_P1_P3_P8_Usuario3
    Duracion_Reparacion_P1_P3_P8_Usuario4
    Duracion_Reparacion_P1_P3_P8_Usuario5
    Duracion_Reparacion_P1_P3_P8_Usuario6
    Duracion_Reparacion_P1_P3_P8_Usuario7
    Duracion_Reparacion_P1_P3_P8_Usuario8
    Duracion_Reparacion_P1_P3_P8_Usuario9
    Duracion_Reparacion_P1_P3_P8_Usuario10
    Duracion_Reparacion_P1_P3_P8_Usuario11
    Duracion_Reparacion_P1_P3_P8_Usuario12
    Duracion_Reparacion_P1_P3_P8_Usuario13
    Duracion_Reparacion_P1_P3_P8_Usuario14];
273
274 SAIFI_P1_P3_P8 = (Tasa_Fallas_P1_P3_P8_Usuario1*Cantidad_Usuarios(1)
    +Tasa_Fallas_P1_P3_P8_Usuario2*Cantidad_Usuarios(2)+
    Tasa_Fallas_P1_P3_P8_Usuario3*Cantidad_Usuarios(3)+
    Tasa_Fallas_P1_P3_P8_Usuario4*Cantidad_Usuarios(4)+
    Tasa_Fallas_P1_P3_P8_Usuario5*Cantidad_Usuarios(5)+
    Tasa_Fallas_P1_P3_P8_Usuario6*Cantidad_Usuarios(6)+
    Tasa_Fallas_P1_P3_P8_Usuario7*Cantidad_Usuarios(7)+
    Tasa_Fallas_P1_P3_P8_Usuario8*Cantidad_Usuarios(8)+
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Tasa_Fallas_P1_P3_P8_Usuario9*Cantidad_Usuarios(9)+
Tasa_Fallas_P1_P3_P8_Usuario10*Cantidad_Usuarios(10)+
Tasa_Fallas_P1_P3_P8_Usuario11*Cantidad_Usuarios(11)+
Tasa_Fallas_P1_P3_P8_Usuario12*Cantidad_Usuarios(12)+
Tasa_Fallas_P1_P3_P8_Usuario13*Cantidad_Usuarios(13)+
Tasa_Fallas_P1_P3_P8_Usuario14*Cantidad_Usuarios(14))/
Total_Consumidores % Number of average failures per year per user
275 SAIDI_P1_P3_P8 = (Duracion_Reparacion_P1_P3_P8_Usuario1*
Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P3_P8_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P3_P8_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P3_P8_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P3_P8_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P3_P8_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P3_P8_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P3_P8_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P3_P8_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P3_P8_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P3_P8_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P3_P8_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P3_P8_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P3_P8_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores % Average repair time
per year per user
276 CAIDI_P1_P3_P8 = SAIDI_P1_P3_P8 / SAIFI_P1_P3_P8 % Average Duration
of an Interruption
277 AENS_P1_P3_P8 = (Duracion_Reparacion_P1_P3_P8_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P3_P8_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P3_P8_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P3_P8_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P3_P8_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P3_P8_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P3_P8_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P3_P8_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P3_P8_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P3_P8_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P3_P8_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P3_P8_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P3_P8_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P3_P8_Usuario14*
Demanda_Usuario(14))/Total_Consumidores % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
278
279 % Analysis with reclosers in P1, in P3 and in P10
280 Tasa_Fallas_P1_P3_P10_Usuario1=Tasa_Fallas_Cargas(1)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
Tasa_Fallas_Troncales(10:14));
281 Tasa_Fallas_P1_P3_P10_Usuario2=Tasa_Fallas_Cargas(2)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
Tasa_Fallas_Troncales(10:14));
282 Tasa_Fallas_P1_P3_P10_Usuario3=Tasa_Fallas_Cargas(3)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
283 Tasa_Fallas_P1_P3_P10_Usuario4=Tasa_Fallas_Cargas(4)+sum(

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Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
284 Tasa_Fallas_P1_P3_P10_Usuario5=Tasa_Fallas_Cargas(5)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(10:14));
285 Tasa_Fallas_P1_P3_P10_Usuario6=Tasa_Fallas_Cargas(6)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(10:14));
286 Tasa_Fallas_P1_P3_P10_Usuario7=Tasa_Fallas_Cargas(7)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(10:14));
287 Tasa_Fallas_P1_P3_P10_Usuario8=Tasa_Fallas_Cargas(8)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(10:14));
288 Tasa_Fallas_P1_P3_P10_Usuario9=Tasa_Fallas_Cargas(9)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(10:14));
289 Tasa_Fallas_P1_P3_P10_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(13:14));
290 Tasa_Fallas_P1_P3_P10_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(13:14));
291 Tasa_Fallas_P1_P3_P10_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(3:4))-sum(
    Tasa_Fallas_Troncales(13:14));
292 Tasa_Fallas_P1_P3_P10_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
293 Tasa_Fallas_P1_P3_P10_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
294
295 Tasa_Fallas_P1_P3_P10_Usuarios=[Tasa_Fallas_P1_P3_P10_Usuario1
    Tasa_Fallas_P1_P3_P10_Usuario2 Tasa_Fallas_P1_P3_P10_Usuario3
    Tasa_Fallas_P1_P3_P10_Usuario4 Tasa_Fallas_P1_P3_P10_Usuario5
    Tasa_Fallas_P1_P3_P10_Usuario6 Tasa_Fallas_P1_P3_P10_Usuario7
    Tasa_Fallas_P1_P3_P10_Usuario8 Tasa_Fallas_P1_P3_P10_Usuario9
    Tasa_Fallas_P1_P3_P10_Usuario10 Tasa_Fallas_P1_P3_P10_Usuario11
    Tasa_Fallas_P1_P3_P10_Usuario12 Tasa_Fallas_P1_P3_P10_Usuario13
    Tasa_Fallas_P1_P3_P10_Usuario14];
296
297 Duracion_Reparacion_P1_P3_P10_Usuario1=U_Cargas(1)+sum(U_Troncales)-
    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
298 Duracion_Reparacion_P1_P3_P10_Usuario2=U_Cargas(2)+sum(U_Troncales)-
    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
299 Duracion_Reparacion_P1_P3_P10_Usuario3=U_Cargas(3)+sum(U_Troncales)-
    sum(U_Troncales(10:12));
300 Duracion_Reparacion_P1_P3_P10_Usuario4=U_Cargas(4)+sum(U_Troncales)-
    sum(U_Troncales(10:12));
301 Duracion_Reparacion_P1_P3_P10_Usuario5=U_Cargas(5)+sum(U_Troncales)-
    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
302 Duracion_Reparacion_P1_P3_P10_Usuario6=U_Cargas(6)+sum(U_Troncales)-
    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
303 Duracion_Reparacion_P1_P3_P10_Usuario7=U_Cargas(7)+sum(U_Troncales)-
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    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
304 Duracion_Reparacion_P1_P3_P10_Usuario8=U_Cargas(8)+sum(U_Troncales)-
    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
305 Duracion_Reparacion_P1_P3_P10_Usuario9=U_Cargas(9)+sum(U_Troncales)-
    sum(U_Troncales(3:4))-sum(U_Troncales(10:14));
306 Duracion_Reparacion_P1_P3_P10_Usuario10=U_Cargas(10)+sum(U_Troncales
    )-sum(U_Troncales(3:4))-sum(U_Troncales(13:14));
307 Duracion_Reparacion_P1_P3_P10_Usuario11=U_Cargas(11)+sum(U_Troncales
    )-sum(U_Troncales(3:4))-sum(U_Troncales(13:14));
308 Duracion_Reparacion_P1_P3_P10_Usuario12=U_Cargas(12)+sum(U_Troncales
    )-sum(U_Troncales(3:4))-sum(U_Troncales(13:14));
309 Duracion_Reparacion_P1_P3_P10_Usuario13=U_Cargas(13)+sum(U_Troncales
    )-sum(U_Troncales(10:12));
310 Duracion_Reparacion_P1_P3_P10_Usuario14=U_Cargas(14)+sum(U_Troncales
    )-sum(U_Troncales(10:12));
311
312 Duracion_Reparacion_P1_P3_P10_Usuarios=[
    Duracion_Reparacion_P1_P3_P10_Usuario1
    Duracion_Reparacion_P1_P3_P10_Usuario2
    Duracion_Reparacion_P1_P3_P10_Usuario3
    Duracion_Reparacion_P1_P3_P10_Usuario4
    Duracion_Reparacion_P1_P3_P10_Usuario5
    Duracion_Reparacion_P1_P3_P10_Usuario6
    Duracion_Reparacion_P1_P3_P10_Usuario7
    Duracion_Reparacion_P1_P3_P10_Usuario8
    Duracion_Reparacion_P1_P3_P10_Usuario9
    Duracion_Reparacion_P1_P3_P10_Usuario10
    Duracion_Reparacion_P1_P3_P10_Usuario11
    Duracion_Reparacion_P1_P3_P10_Usuario12
    Duracion_Reparacion_P1_P3_P10_Usuario13
    Duracion_Reparacion_P1_P3_P10_Usuario14];
313
314 SAIFI_P1_P3_P10 = (Tasa_Fallas_P1_P3_P10_Usuario1*Cantidad_Usuarios
    (1)+Tasa_Fallas_P1_P3_P10_Usuario2*Cantidad_Usuarios(2)+
    Tasa_Fallas_P1_P3_P10_Usuario3*Cantidad_Usuarios(3)+
    Tasa_Fallas_P1_P3_P10_Usuario4*Cantidad_Usuarios(4)+
    Tasa_Fallas_P1_P3_P10_Usuario5*Cantidad_Usuarios(5)+
    Tasa_Fallas_P1_P3_P10_Usuario6*Cantidad_Usuarios(6)+
    Tasa_Fallas_P1_P3_P10_Usuario7*Cantidad_Usuarios(7)+
    Tasa_Fallas_P1_P3_P10_Usuario8*Cantidad_Usuarios(8)+
    Tasa_Fallas_P1_P3_P10_Usuario9*Cantidad_Usuarios(9)+
    Tasa_Fallas_P1_P3_P10_Usuario10*Cantidad_Usuarios(10)+
    Tasa_Fallas_P1_P3_P10_Usuario11*Cantidad_Usuarios(11)+
    Tasa_Fallas_P1_P3_P10_Usuario12*Cantidad_Usuarios(12)+
    Tasa_Fallas_P1_P3_P10_Usuario13*Cantidad_Usuarios(13)+
    Tasa_Fallas_P1_P3_P10_Usuario14*Cantidad_Usuarios(14))/
    Total_Consumidores % Number of average failures per year per user
315 SAIDI_P1_P3_P10 = (Duracion_Reparacion_P1_P3_P10_Usuario1*
    Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P3_P10_Usuario2*
    Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P3_P10_Usuario3*
    Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P3_P10_Usuario4*
    Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P3_P10_Usuario5*

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Cantidad_Usuarios (5)+Duracion_Reparacion_P1_P3_P10_Usuario6*
Cantidad_Usuarios (6)+Duracion_Reparacion_P1_P3_P10_Usuario7*
Cantidad_Usuarios (7)+Duracion_Reparacion_P1_P3_P10_Usuario8*
Cantidad_Usuarios (8)+Duracion_Reparacion_P1_P3_P10_Usuario9*
Cantidad_Usuarios (9)+Duracion_Reparacion_P1_P3_P10_Usuario10*
Cantidad_Usuarios (10)+Duracion_Reparacion_P1_P3_P10_Usuario11*
Cantidad_Usuarios (11)+Duracion_Reparacion_P1_P3_P10_Usuario12*
Cantidad_Usuarios (12)+Duracion_Reparacion_P1_P3_P10_Usuario13*
Cantidad_Usuarios (13)+Duracion_Reparacion_P1_P3_P10_Usuario14*
Cantidad_Usuarios (14))/Total_Consumidores % Average repair time
per year per user
316 CAIDI_P1_P3_P10 = SAIDI_P1_P3_P10 / SAIFI_P1_P3_P10 % Average
Duration of an Interruption
317 AENS_P1_P3_P10 = (Duracion_Reparacion_P1_P3_P10_Usuario1*
Demanda_Usuario (1)+Duracion_Reparacion_P1_P3_P10_Usuario2*
Demanda_Usuario (2)+Duracion_Reparacion_P1_P3_P10_Usuario3*
Demanda_Usuario (3)+Duracion_Reparacion_P1_P3_P10_Usuario4*
Demanda_Usuario (4)+Duracion_Reparacion_P1_P3_P10_Usuario5*
Demanda_Usuario (5)+Duracion_Reparacion_P1_P3_P10_Usuario6*
Demanda_Usuario (6)+Duracion_Reparacion_P1_P3_P10_Usuario7*
Demanda_Usuario (7)+Duracion_Reparacion_P1_P3_P10_Usuario8*
Demanda_Usuario (8)+Duracion_Reparacion_P1_P3_P10_Usuario9*
Demanda_Usuario (9)+Duracion_Reparacion_P1_P3_P10_Usuario10*
Demanda_Usuario (10)+Duracion_Reparacion_P1_P3_P10_Usuario11*
Demanda_Usuario (11)+Duracion_Reparacion_P1_P3_P10_Usuario12*
Demanda_Usuario (12)+Duracion_Reparacion_P1_P3_P10_Usuario13*
Demanda_Usuario (13)+Duracion_Reparacion_P1_P3_P10_Usuario14*
Demanda_Usuario (14))/Total_Consumidores % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
318
319 % Analysis with reclosers in P1, in P5 and in P8
320 Tasa_Fallas_P1_P5_P8_Usuario1=Tasa_Fallas_Cargas (1)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:9));
321 Tasa_Fallas_P1_P5_P8_Usuario2=Tasa_Fallas_Cargas (2)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:9));
322 Tasa_Fallas_P1_P5_P8_Usuario3=Tasa_Fallas_Cargas (3)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:9));
323 Tasa_Fallas_P1_P5_P8_Usuario4=Tasa_Fallas_Cargas (4)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:9));
324 Tasa_Fallas_P1_P5_P8_Usuario5=Tasa_Fallas_Cargas (5)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (8:9));
325 Tasa_Fallas_P1_P5_P8_Usuario6=Tasa_Fallas_Cargas (6)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (8:9));
326 Tasa_Fallas_P1_P5_P8_Usuario7=Tasa_Fallas_Cargas (7)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (8:9));
327 Tasa_Fallas_P1_P5_P8_Usuario8=Tasa_Fallas_Cargas (8)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:7));
328 Tasa_Fallas_P1_P5_P8_Usuario9=Tasa_Fallas_Cargas (9)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:7));
329 Tasa_Fallas_P1_P5_P8_Usuario10=Tasa_Fallas_Cargas (10)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales (5:9));
330 Tasa_Fallas_P1_P5_P8_Usuario11=Tasa_Fallas_Cargas (11)+sum(

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    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:9));
331 Tasa_Fallas_P1_P5_P8_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:9));
332 Tasa_Fallas_P1_P5_P8_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:9));
333 Tasa_Fallas_P1_P5_P8_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:9));
334
335 Tasa_Fallas_P1_P5_P8_Usuarios=[Tasa_Fallas_P1_P5_P8_Usuario1
    Tasa_Fallas_P1_P5_P8_Usuario2 Tasa_Fallas_P1_P5_P8_Usuario3
    Tasa_Fallas_P1_P5_P8_Usuario4 Tasa_Fallas_P1_P5_P8_Usuario5
    Tasa_Fallas_P1_P5_P8_Usuario6 Tasa_Fallas_P1_P5_P8_Usuario7
    Tasa_Fallas_P1_P5_P8_Usuario8 Tasa_Fallas_P1_P5_P8_Usuario9
    Tasa_Fallas_P1_P5_P8_Usuario10 Tasa_Fallas_P1_P5_P8_Usuario11
    Tasa_Fallas_P1_P5_P8_Usuario12 Tasa_Fallas_P1_P5_P8_Usuario13
    Tasa_Fallas_P1_P5_P8_Usuario14];
336
337 Duracion_Reparacion_P1_P5_P8_Usuario1=U_Cargas(1)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
338 Duracion_Reparacion_P1_P5_P8_Usuario2=U_Cargas(2)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
339 Duracion_Reparacion_P1_P5_P8_Usuario3=U_Cargas(3)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
340 Duracion_Reparacion_P1_P5_P8_Usuario4=U_Cargas(4)+sum(U_Troncales)-
    sum(U_Troncales(5:9));
341 Duracion_Reparacion_P1_P5_P8_Usuario5=U_Cargas(5)+sum(U_Troncales)-
    sum(U_Troncales(8:9));
342 Duracion_Reparacion_P1_P5_P8_Usuario6=U_Cargas(6)+sum(U_Troncales)-
    sum(U_Troncales(8:9));
343 Duracion_Reparacion_P1_P5_P8_Usuario7=U_Cargas(7)+sum(U_Troncales)-
    sum(U_Troncales(8:9));
344 Duracion_Reparacion_P1_P5_P8_Usuario8=U_Cargas(8)+sum(U_Troncales)-
    sum(U_Troncales(5:7));
345 Duracion_Reparacion_P1_P5_P8_Usuario9=U_Cargas(9)+sum(U_Troncales)-
    sum(U_Troncales(5:7));
346 Duracion_Reparacion_P1_P5_P8_Usuario10=U_Cargas(10)+sum(U_Troncales)
    -sum(U_Troncales(5:9));
347 Duracion_Reparacion_P1_P5_P8_Usuario11=U_Cargas(11)+sum(U_Troncales)
    -sum(U_Troncales(5:9));
348 Duracion_Reparacion_P1_P5_P8_Usuario12=U_Cargas(12)+sum(U_Troncales)
    -sum(U_Troncales(5:9));
349 Duracion_Reparacion_P1_P5_P8_Usuario13=U_Cargas(13)+sum(U_Troncales)
    -sum(U_Troncales(5:9));
350 Duracion_Reparacion_P1_P5_P8_Usuario14=U_Cargas(14)+sum(U_Troncales)
    -sum(U_Troncales(5:9));
351
352 Duracion_Reparacion_P1_P5_P8_Usuarios=[
    Duracion_Reparacion_P1_P5_P8_Usuario1
    Duracion_Reparacion_P1_P5_P8_Usuario2
    Duracion_Reparacion_P1_P5_P8_Usuario3
    Duracion_Reparacion_P1_P5_P8_Usuario4
    Duracion_Reparacion_P1_P5_P8_Usuario5

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Duracion_Reparacion_P1_P5_P8_Usuario6
Duracion_Reparacion_P1_P5_P8_Usuario7
Duracion_Reparacion_P1_P5_P8_Usuario8
Duracion_Reparacion_P1_P5_P8_Usuario9
Duracion_Reparacion_P1_P5_P8_Usuario10
Duracion_Reparacion_P1_P5_P8_Usuario11
Duracion_Reparacion_P1_P5_P8_Usuario12
Duracion_Reparacion_P1_P5_P8_Usuario13
Duracion_Reparacion_P1_P5_P8_Usuario14];
353
354 SAIFI_P1_P5_P8 = (Tasa_Fallas_P1_P5_P8_Usuario1*Cantidad_Usuarios(1)
+Tasa_Fallas_P1_P5_P8_Usuario2*Cantidad_Usuarios(2)+
Tasa_Fallas_P1_P5_P8_Usuario3*Cantidad_Usuarios(3)+
Tasa_Fallas_P1_P5_P8_Usuario4*Cantidad_Usuarios(4)+
Tasa_Fallas_P1_P5_P8_Usuario5*Cantidad_Usuarios(5)+
Tasa_Fallas_P1_P5_P8_Usuario6*Cantidad_Usuarios(6)+
Tasa_Fallas_P1_P5_P8_Usuario7*Cantidad_Usuarios(7)+
Tasa_Fallas_P1_P5_P8_Usuario8*Cantidad_Usuarios(8)+
Tasa_Fallas_P1_P5_P8_Usuario9*Cantidad_Usuarios(9)+
Tasa_Fallas_P1_P5_P8_Usuario10*Cantidad_Usuarios(10)+
Tasa_Fallas_P1_P5_P8_Usuario11*Cantidad_Usuarios(11)+
Tasa_Fallas_P1_P5_P8_Usuario12*Cantidad_Usuarios(12)+
Tasa_Fallas_P1_P5_P8_Usuario13*Cantidad_Usuarios(13)+
Tasa_Fallas_P1_P5_P8_Usuario14*Cantidad_Usuarios(14))/
Total_Consumidores % Number of average failures per year per user
355 SAIDI_P1_P5_P8 = (Duracion_Reparacion_P1_P5_P8_Usuario1*
Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P5_P8_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P5_P8_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P5_P8_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P5_P8_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P5_P8_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P5_P8_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P5_P8_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P5_P8_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P5_P8_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P5_P8_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P5_P8_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P5_P8_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P5_P8_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores % Average repair time
per year per user
356 CAIDI_P1_P5_P8 = SAIDI_P1_P5_P8 / SAIFI_P1_P5_P8 % Average Duration
of an Interruption
357 AENS_P1_P5_P8 = (Duracion_Reparacion_P1_P5_P8_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P5_P8_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P5_P8_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P5_P8_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P5_P8_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P5_P8_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P5_P8_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P5_P8_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P5_P8_Usuario9*

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Demanda_Usuario(9)+Duracion_Reparacion_P1_P5_P8_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P5_P8_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P5_P8_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P5_P8_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P5_P8_Usuario14*
Demanda_Usuario(14))/Total_Consumidores % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
358
359 % Analysis with reclosers in P1, in P5 and in P10
360 Tasa_Fallas_P1_P5_P10_Usuario1=Tasa_Fallas_Cargas(1)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
361 Tasa_Fallas_P1_P5_P10_Usuario2=Tasa_Fallas_Cargas(2)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
362 Tasa_Fallas_P1_P5_P10_Usuario3=Tasa_Fallas_Cargas(3)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
363 Tasa_Fallas_P1_P5_P10_Usuario4=Tasa_Fallas_Cargas(4)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
364 Tasa_Fallas_P1_P5_P10_Usuario5=Tasa_Fallas_Cargas(5)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
365 Tasa_Fallas_P1_P5_P10_Usuario6=Tasa_Fallas_Cargas(6)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
366 Tasa_Fallas_P1_P5_P10_Usuario7=Tasa_Fallas_Cargas(7)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
367 Tasa_Fallas_P1_P5_P10_Usuario8=Tasa_Fallas_Cargas(8)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
368 Tasa_Fallas_P1_P5_P10_Usuario9=Tasa_Fallas_Cargas(9)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
369 Tasa_Fallas_P1_P5_P10_Usuario10=Tasa_Fallas_Cargas(10)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
370 Tasa_Fallas_P1_P5_P10_Usuario11=Tasa_Fallas_Cargas(11)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
371 Tasa_Fallas_P1_P5_P10_Usuario12=Tasa_Fallas_Cargas(12)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7));
372 Tasa_Fallas_P1_P5_P10_Usuario13=Tasa_Fallas_Cargas(13)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
373 Tasa_Fallas_P1_P5_P10_Usuario14=Tasa_Fallas_Cargas(14)+sum(
      Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(5:7))-sum(
      Tasa_Fallas_Troncales(10:12));
374
375 Tasa_Fallas_P1_P5_P10_Usuarios=[Tasa_Fallas_P1_P5_P10_Usuario1
      Tasa_Fallas_P1_P5_P10_Usuario2 Tasa_Fallas_P1_P5_P10_Usuario3
      Tasa_Fallas_P1_P5_P10_Usuario4 Tasa_Fallas_P1_P5_P10_Usuario5
      Tasa_Fallas_P1_P5_P10_Usuario6 Tasa_Fallas_P1_P5_P10_Usuario7
      Tasa_Fallas_P1_P5_P10_Usuario8 Tasa_Fallas_P1_P5_P10_Usuario9
      Tasa_Fallas_P1_P5_P10_Usuario10 Tasa_Fallas_P1_P5_P10_Usuario11

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Tasa_Fallas_P1_P5_P10_Usuario12 Tasa_Fallas_P1_P5_P10_Usuario13
Tasa_Fallas_P1_P5_P10_Usuario14];
376
377 Duracion_Reparacion_P1_P5_P10_Usuario1=U_Cargas(1)+sum(U_Troncales)-
sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
378 Duracion_Reparacion_P1_P5_P10_Usuario2=U_Cargas(2)+sum(U_Troncales)-
sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
379 Duracion_Reparacion_P1_P5_P10_Usuario3=U_Cargas(3)+sum(U_Troncales)-
sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
380 Duracion_Reparacion_P1_P5_P10_Usuario4=U_Cargas(4)+sum(U_Troncales)-
sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
381 Duracion_Reparacion_P1_P5_P10_Usuario5=U_Cargas(5)+sum(U_Troncales)-
sum(U_Troncales(10:12));
382 Duracion_Reparacion_P1_P5_P10_Usuario6=U_Cargas(6)+sum(U_Troncales)-
sum(U_Troncales(10:12));
383 Duracion_Reparacion_P1_P5_P10_Usuario7=U_Cargas(7)+sum(U_Troncales)-
sum(U_Troncales(10:12));
384 Duracion_Reparacion_P1_P5_P10_Usuario8=U_Cargas(8)+sum(U_Troncales)-
sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
385 Duracion_Reparacion_P1_P5_P10_Usuario9=U_Cargas(9)+sum(U_Troncales)-
sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
386 Duracion_Reparacion_P1_P5_P10_Usuario10=U_Cargas(10)+sum(U_Troncales
)-sum(U_Troncales(5:7));
387 Duracion_Reparacion_P1_P5_P10_Usuario11=U_Cargas(11)+sum(U_Troncales
)-sum(U_Troncales(5:7));
388 Duracion_Reparacion_P1_P5_P10_Usuario12=U_Cargas(12)+sum(U_Troncales
)-sum(U_Troncales(5:7));
389 Duracion_Reparacion_P1_P5_P10_Usuario13=U_Cargas(13)+sum(U_Troncales
)-sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
390 Duracion_Reparacion_P1_P5_P10_Usuario14=U_Cargas(14)+sum(U_Troncales
)-sum(U_Troncales(5:7))-sum(U_Troncales(10:12));
391
392 Duracion_Reparacion_P1_P5_P10_Usuarios=[
Duracion_Reparacion_P1_P5_P10_Usuario1
Duracion_Reparacion_P1_P5_P10_Usuario2
Duracion_Reparacion_P1_P5_P10_Usuario3
Duracion_Reparacion_P1_P5_P10_Usuario4
Duracion_Reparacion_P1_P5_P10_Usuario5
Duracion_Reparacion_P1_P5_P10_Usuario6
Duracion_Reparacion_P1_P5_P10_Usuario7
Duracion_Reparacion_P1_P5_P10_Usuario8
Duracion_Reparacion_P1_P5_P10_Usuario9
Duracion_Reparacion_P1_P5_P10_Usuario10
Duracion_Reparacion_P1_P5_P10_Usuario11
Duracion_Reparacion_P1_P5_P10_Usuario12
Duracion_Reparacion_P1_P5_P10_Usuario13
Duracion_Reparacion_P1_P5_P10_Usuario14];
393
394 SAIFI_P1_P5_P10 = (Tasa_Fallas_P1_P5_P10_Usuario1*Cantidad_Usuarios
(1)+Tasa_Fallas_P1_P5_P10_Usuario2*Cantidad_Usuarios(2)+
Tasa_Fallas_P1_P5_P10_Usuario3*Cantidad_Usuarios(3)+
Tasa_Fallas_P1_P5_P10_Usuario4*Cantidad_Usuarios(4)+
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Tasa_Fallas_P1_P5_P10_Usuario5*Cantidad_Usuarios(5)+
Tasa_Fallas_P1_P5_P10_Usuario6*Cantidad_Usuarios(6)+
Tasa_Fallas_P1_P5_P10_Usuario7*Cantidad_Usuarios(7)+
Tasa_Fallas_P1_P5_P10_Usuario8*Cantidad_Usuarios(8)+
Tasa_Fallas_P1_P5_P10_Usuario9*Cantidad_Usuarios(9)+
Tasa_Fallas_P1_P5_P10_Usuario10*Cantidad_Usuarios(10)+
Tasa_Fallas_P1_P5_P10_Usuario11*Cantidad_Usuarios(11)+
Tasa_Fallas_P1_P5_P10_Usuario12*Cantidad_Usuarios(12)+
Tasa_Fallas_P1_P5_P10_Usuario13*Cantidad_Usuarios(13)+
Tasa_Fallas_P1_P5_P10_Usuario14*Cantidad_Usuarios(14))/
Total_Consumidores % Number of average failures per year per user
395 SAIDI_P1_P5_P10 = (Duracion_Reparacion_P1_P5_P10_Usuario1*
Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P5_P10_Usuario2*
Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P5_P10_Usuario3*
Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P5_P10_Usuario4*
Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P5_P10_Usuario5*
Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P5_P10_Usuario6*
Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P5_P10_Usuario7*
Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P5_P10_Usuario8*
Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P5_P10_Usuario9*
Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P5_P10_Usuario10*
Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P5_P10_Usuario11*
Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P5_P10_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P5_P10_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P5_P10_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores % Average repair time
per year per user
396 CAIDI_P1_P5_P10 = SAIDI_P1_P5_P10 / SAIFI_P1_P5_P10 % Average
Duration of an Interruption
397 AENS_P1_P5_P10 = (Duracion_Reparacion_P1_P5_P10_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P5_P10_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P5_P10_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P5_P10_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P5_P10_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P5_P10_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P5_P10_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P5_P10_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P5_P10_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P5_P10_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P5_P10_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P5_P10_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P5_P10_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P5_P10_Usuario14*
Demanda_Usuario(14))/Total_Consumidores % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
398
399 % Analysis with reclosers in P1, in P8 and in P10
400 Tasa_Fallas_P1_P8_P10_Usuario1=Tasa_Fallas_Cargas(1)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
401 Tasa_Fallas_P1_P8_P10_Usuario2=Tasa_Fallas_Cargas(2)+sum(
Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
402 Tasa_Fallas_P1_P8_P10_Usuario3=Tasa_Fallas_Cargas(3)+sum(

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Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
403 Tasa_Fallas_P1_P8_P10_Usuario4=Tasa_Fallas_Cargas(4)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
404 Tasa_Fallas_P1_P8_P10_Usuario5=Tasa_Fallas_Cargas(5)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
405 Tasa_Fallas_P1_P8_P10_Usuario6=Tasa_Fallas_Cargas(6)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
406 Tasa_Fallas_P1_P8_P10_Usuario7=Tasa_Fallas_Cargas(7)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
407 Tasa_Fallas_P1_P8_P10_Usuario8=Tasa_Fallas_Cargas(8)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
408 Tasa_Fallas_P1_P8_P10_Usuario9=Tasa_Fallas_Cargas(9)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(10:12));
409 Tasa_Fallas_P1_P8_P10_Usuario10=Tasa_Fallas_Cargas(10)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:9));
410 Tasa_Fallas_P1_P8_P10_Usuario11=Tasa_Fallas_Cargas(11)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:9));
411 Tasa_Fallas_P1_P8_P10_Usuario12=Tasa_Fallas_Cargas(12)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:9));
412 Tasa_Fallas_P1_P8_P10_Usuario13=Tasa_Fallas_Cargas(13)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
413 Tasa_Fallas_P1_P8_P10_Usuario14=Tasa_Fallas_Cargas(14)+sum(
    Tasa_Fallas_Troncales)-sum(Tasa_Fallas_Troncales(8:12));
414
415 Tasa_Fallas_P1_P8_P10_Usuarios=[Tasa_Fallas_P1_P8_P10_Usuario1
    Tasa_Fallas_P1_P8_P10_Usuario2 Tasa_Fallas_P1_P8_P10_Usuario3
    Tasa_Fallas_P1_P8_P10_Usuario4 Tasa_Fallas_P1_P8_P10_Usuario5
    Tasa_Fallas_P1_P8_P10_Usuario6 Tasa_Fallas_P1_P8_P10_Usuario7
    Tasa_Fallas_P1_P8_P10_Usuario8 Tasa_Fallas_P1_P8_P10_Usuario9
    Tasa_Fallas_P1_P8_P10_Usuario10 Tasa_Fallas_P1_P8_P10_Usuario11
    Tasa_Fallas_P1_P8_P10_Usuario12 Tasa_Fallas_P1_P8_P10_Usuario13
    Tasa_Fallas_P1_P8_P10_Usuario14];
416
417 Duracion_Reparacion_P1_P8_P10_Usuario1=U_Cargas(1)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
418 Duracion_Reparacion_P1_P8_P10_Usuario2=U_Cargas(2)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
419 Duracion_Reparacion_P1_P8_P10_Usuario3=U_Cargas(3)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
420 Duracion_Reparacion_P1_P8_P10_Usuario4=U_Cargas(4)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
421 Duracion_Reparacion_P1_P8_P10_Usuario5=U_Cargas(5)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
422 Duracion_Reparacion_P1_P8_P10_Usuario6=U_Cargas(6)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
423 Duracion_Reparacion_P1_P8_P10_Usuario7=U_Cargas(7)+sum(U_Troncales)-
    sum(U_Troncales(8:12));
424 Duracion_Reparacion_P1_P8_P10_Usuario8=U_Cargas(8)+sum(U_Troncales)-
    sum(U_Troncales(10:12));
425 Duracion_Reparacion_P1_P8_P10_Usuario9=U_Cargas(9)+sum(U_Troncales)-
    sum(U_Troncales(10:12));
426 Duracion_Reparacion_P1_P8_P10_Usuario10=U_Cargas(10)+sum(U_Troncales
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    )-sum(U_Troncales(8:9));
427 Duracion_Reparacion_P1_P8_P10_Usuario11=U_Cargas(11)+sum(U_Troncales
    )-sum(U_Troncales(8:9));
428 Duracion_Reparacion_P1_P8_P10_Usuario12=U_Cargas(12)+sum(U_Troncales
    )-sum(U_Troncales(8:9));
429 Duracion_Reparacion_P1_P8_P10_Usuario13=U_Cargas(13)+sum(U_Troncales
    )-sum(U_Troncales(8:12));
430 Duracion_Reparacion_P1_P8_P10_Usuario14=U_Cargas(14)+sum(U_Troncales
    )-sum(U_Troncales(8:12));
431
432 Duracion_Reparacion_P1_P8_P10_Usuarios=[
    Duracion_Reparacion_P1_P8_P10_Usuario1
    Duracion_Reparacion_P1_P8_P10_Usuario2
    Duracion_Reparacion_P1_P8_P10_Usuario3
    Duracion_Reparacion_P1_P8_P10_Usuario4
    Duracion_Reparacion_P1_P8_P10_Usuario5
    Duracion_Reparacion_P1_P8_P10_Usuario6
    Duracion_Reparacion_P1_P8_P10_Usuario7
    Duracion_Reparacion_P1_P8_P10_Usuario8
    Duracion_Reparacion_P1_P8_P10_Usuario9
    Duracion_Reparacion_P1_P8_P10_Usuario10
    Duracion_Reparacion_P1_P8_P10_Usuario11
    Duracion_Reparacion_P1_P8_P10_Usuario12
    Duracion_Reparacion_P1_P8_P10_Usuario13
    Duracion_Reparacion_P1_P8_P10_Usuario14];
433
434 SAIFI_P1_P8_P10 = (Tasa_Fallas_P1_P8_P10_Usuario1*Cantidad_Usuarios
    (1)+Tasa_Fallas_P1_P8_P10_Usuario2*Cantidad_Usuarios(2)+
    Tasa_Fallas_P1_P8_P10_Usuario3*Cantidad_Usuarios(3)+
    Tasa_Fallas_P1_P8_P10_Usuario4*Cantidad_Usuarios(4)+
    Tasa_Fallas_P1_P8_P10_Usuario5*Cantidad_Usuarios(5)+
    Tasa_Fallas_P1_P8_P10_Usuario6*Cantidad_Usuarios(6)+
    Tasa_Fallas_P1_P8_P10_Usuario7*Cantidad_Usuarios(7)+
    Tasa_Fallas_P1_P8_P10_Usuario8*Cantidad_Usuarios(8)+
    Tasa_Fallas_P1_P8_P10_Usuario9*Cantidad_Usuarios(9)+
    Tasa_Fallas_P1_P8_P10_Usuario10*Cantidad_Usuarios(10)+
    Tasa_Fallas_P1_P8_P10_Usuario11*Cantidad_Usuarios(11)+
    Tasa_Fallas_P1_P8_P10_Usuario12*Cantidad_Usuarios(12)+
    Tasa_Fallas_P1_P8_P10_Usuario13*Cantidad_Usuarios(13)+
    Tasa_Fallas_P1_P8_P10_Usuario14*Cantidad_Usuarios(14))/
    Total_Consumidores % Number of average failures per year per user
435 SAIDI_P1_P8_P10 = (Duracion_Reparacion_P1_P8_P10_Usuario1*
    Cantidad_Usuarios(1)+Duracion_Reparacion_P1_P8_P10_Usuario2*
    Cantidad_Usuarios(2)+Duracion_Reparacion_P1_P8_P10_Usuario3*
    Cantidad_Usuarios(3)+Duracion_Reparacion_P1_P8_P10_Usuario4*
    Cantidad_Usuarios(4)+Duracion_Reparacion_P1_P8_P10_Usuario5*
    Cantidad_Usuarios(5)+Duracion_Reparacion_P1_P8_P10_Usuario6*
    Cantidad_Usuarios(6)+Duracion_Reparacion_P1_P8_P10_Usuario7*
    Cantidad_Usuarios(7)+Duracion_Reparacion_P1_P8_P10_Usuario8*
    Cantidad_Usuarios(8)+Duracion_Reparacion_P1_P8_P10_Usuario9*
    Cantidad_Usuarios(9)+Duracion_Reparacion_P1_P8_P10_Usuario10*
    Cantidad_Usuarios(10)+Duracion_Reparacion_P1_P8_P10_Usuario11*

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Cantidad_Usuarios(11)+Duracion_Reparacion_P1_P8_P10_Usuario12*
Cantidad_Usuarios(12)+Duracion_Reparacion_P1_P8_P10_Usuario13*
Cantidad_Usuarios(13)+Duracion_Reparacion_P1_P8_P10_Usuario14*
Cantidad_Usuarios(14))/Total_Consumidores % Average repair time
per year per user
436 CAIDI_P1_P8_P10 = SAIDI_P1_P8_P10 / SAIFI_P1_P8_P10 % Average
Duration of an Interruption
437 AENS_P1_P8_P10 = (Duracion_Reparacion_P1_P8_P10_Usuario1*
Demanda_Usuario(1)+Duracion_Reparacion_P1_P8_P10_Usuario2*
Demanda_Usuario(2)+Duracion_Reparacion_P1_P8_P10_Usuario3*
Demanda_Usuario(3)+Duracion_Reparacion_P1_P8_P10_Usuario4*
Demanda_Usuario(4)+Duracion_Reparacion_P1_P8_P10_Usuario5*
Demanda_Usuario(5)+Duracion_Reparacion_P1_P8_P10_Usuario6*
Demanda_Usuario(6)+Duracion_Reparacion_P1_P8_P10_Usuario7*
Demanda_Usuario(7)+Duracion_Reparacion_P1_P8_P10_Usuario8*
Demanda_Usuario(8)+Duracion_Reparacion_P1_P8_P10_Usuario9*
Demanda_Usuario(9)+Duracion_Reparacion_P1_P8_P10_Usuario10*
Demanda_Usuario(10)+Duracion_Reparacion_P1_P8_P10_Usuario11*
Demanda_Usuario(11)+Duracion_Reparacion_P1_P8_P10_Usuario12*
Demanda_Usuario(12)+Duracion_Reparacion_P1_P8_P10_Usuario13*
Demanda_Usuario(13)+Duracion_Reparacion_P1_P8_P10_Usuario14*
Demanda_Usuario(14))/Total_Consumidores % Average energy NOT
supplied per year per user (kWh Not Supplied / User)
438
439 % Multicriteria analysis for one (1) additional recloser to P1 and
P2. They are considering the location in P2 as a previously
analysed winning alternative. One recloser is considered in P1
and another in P2, and a third recloser's optimal location is
calculated as sectionalising coordination.
440
441 Matriz_Decision1=[SAIFI_P1_P2_P3 SAIFI_P1_P2_P5 SAIFI_P1_P2_P8
SAIFI_P1_P2_P10 SAIFI_P1_P3_P5 SAIFI_P1_P3_P8 SAIFI_P1_P3_P10
SAIFI_P1_P5_P8 SAIFI_P1_P5_P10 SAIFI_P1_P8_P10; ...
442 SAIDI_P1_P2_P3 SAIDI_P1_P2_P5 SAIDI_P1_P2_P8 SAIDI_P1_P2_P10
SAIDI_P1_P3_P5 SAIDI_P1_P3_P8 SAIDI_P1_P3_P10 SAIDI_P1_P5_P8
SAIDI_P1_P5_P10 SAIDI_P1_P8_P10; ...
443 CAIDI_P1_P2_P3 CAIDI_P1_P2_P5 CAIDI_P1_P2_P8 CAIDI_P1_P2_P10
CAIDI_P1_P3_P5 CAIDI_P1_P3_P8 CAIDI_P1_P3_P10 CAIDI_P1_P5_P8
CAIDI_P1_P5_P10 CAIDI_P1_P8_P10; ...
444 AENS_P1_P2_P3 AENS_P1_P2_P5 AENS_P1_P2_P8 AENS_P1_P2_P10
AENS_P1_P3_P5 AENS_P1_P3_P8 AENS_P1_P3_P10 AENS_P1_P5_P8
AENS_P1_P5_P10 AENS_P1_P8_P10]
445
446 coders1 = {'P1, P2, P3' , 'P1, P2, P5', 'P1, P2, P8', 'P1, P2, P10',
'P1, P3, P5', 'P1, P3, P8', 'P1, P3, P10', 'P1, P5, P8', 'P1, P5
, P10', 'P1, P8, P10'}
447
448 for i=1:1:length(Matriz_Decision1(1,:))
449 for j=1:1:length(Matriz_Decision1(:,1))
450 Matriz_Normalizada1(j,:)=(1/sum(Matriz_Decision1(j,:)))*
Matriz_Decision1(j,:);
451 Matriz_Normalizada_Rango1(j,i)=(Matriz_Decision1(j,i)-min(

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    Matriz_Decision1(j,:))/(max(Matriz_Decision1(j,:))-min(
    Matriz_Decision1(j,:))); % Normalization by Range
452     end
453 end
454 Matriz_Normalizada_Rango1;
455 for n=1:1:length(Matriz_Decision1(:,1))
456 Desviacion_estandar1(n,:)=std(Matriz_Normalizada1(n,:));
457 end
458 Desviacion_estandar1;
459 R = corrcoef(Matriz_Normalizada1');
460 for m=1:1:length(Matriz_Decision1(:,1))
461 Ponderacion1=Desviacion_estandar1.*sum(1-R(:,m));
462 end
463 Ponderacion1;
464
465 Ponderacion_Normalizada1=(1/sum(Ponderacion1))*Ponderacion1;
466
467 cont1=0;
468 for k=1:1:j
469     Sumas_Ponderadas1 = Matriz_Normalizada_Rango1(k,:).*
470         Ponderacion_Normalizada1 (k) + cont1;
471     cont=Sumas_Ponderadas1;
472 end
473 Sumas_Ponderadas1;
474 win_case1 = min (Sumas_Ponderadas1); [Escenario_Ganador1(x)] = find(
475     Sumas_Ponderadas1 == win_case1); % position of the winning
476     alternative
477 end
478 % Analysis in Montecarlo
479 P1_P2_P3=0;
480 P1_P2_P5=0;
481 P1_P2_P8=0;
482 P1_P2_P10=0;
483 P1_P3_P5=0;
484 P1_P3_P8=0;
485 P1_P3_P10=0;
486 P1_P5_P8=0;
487 P1_P5_P10=0;
488 P1_P8_P10=0;
489
490 for i=1:1:N
491     if Escenario_Ganador1(i)==1
492         P1_P2_P3=1+P1_P2_P3;
493     end
494     if Escenario_Ganador1(i)==2
495         P1_P2_P5=1+P1_P2_P5;
496     end
497     if Escenario_Ganador1(i)==3
498         P1_P2_P8=1+P1_P2_P8;
499     end
500     if Escenario_Ganador1(i)==4

```

```
499     P1_P2_P10=1+P1_P2_P10;
500 end
501 if Escenario_Ganador1(i)==5
502     P1_P3_P5=1+P1_P3_P5;
503 end
504 if Escenario_Ganador1(i)==6
505     P1_P3_P8=1+P1_P3_P8;
506 end
507 if Escenario_Ganador1(i)==7
508     P1_P3_P10=1+P1_P3_P10;
509 end
510 if Escenario_Ganador1(i)==8
511     P1_P5_P8=1+P1_P5_P8;
512 end
513 if Escenario_Ganador1(i)==9
514     P1_P5_P10=1+P1_P5_P10;
515 end
516 if Escenario_Ganador1(i)==10
517     P1_P8_P10=1+P1_P8_P10;
518 end
519 end
520 P1_P2_P3
521 P1_P2_P5
522 P1_P2_P8
523 P1_P2_P10
524 P1_P3_P5
525 P1_P3_P8
526 P1_P3_P10
527 P1_P5_P8
528 P1_P5_P10
529 P1_P8_P10
530 Probabilidad_P1_P2_P3=P1_P2_P3/N
531 Probabilidad_P1_P2_P5=P1_P2_P5/N
532 Probabilidad_P1_P2_P8=P1_P2_P8/N
533 Probabilidad_P1_P2_P10=P1_P2_P10/N
534 Probabilidad_P1_P3_P5=P1_P3_P5/N
535 Probabilidad_P1_P3_P8=P1_P3_P8/N
536 Probabilidad_P1_P3_P10=P1_P3_P10/N
537 Probabilidad_P1_P5_P8=P1_P5_P8/N
538 Probabilidad_P1_P5_P10=P1_P5_P10/N
539 Probabilidad_P1_P8_P10=P1_P8_P10/N
540
541 Suma_Probabilidades=Probabilidad_P1_P2_P3+Probabilidad_P1_P2_P5+
    Probabilidad_P1_P2_P8+Probabilidad_P1_P2_P10+
    Probabilidad_P1_P3_P5+Probabilidad_P1_P3_P8+
    Probabilidad_P1_P3_P10+Probabilidad_P1_P5_P8+
    Probabilidad_P1_P5_P10+Probabilidad_P1_P8_P10
542 toc
543
544 figure(1)
545 pie3([P1_P2_P3 P1_P2_P5 P1_P2_P8 P1_P2_P10 P1_P3_P5 P1_P3_P8
    P1_P3_P10 P1_P5_P8 P1_P5_P10 P1_P8_P10])
```

```
546 legend('P1 P2 P3','P1 P2 P5','P1 P2 P8','P1 P2 P10','P1_P3_P5','  
      P1_P3_P8','P1_P3_P10','P1_P5_P8','P1_P5_P10','P1_P8_P10')  
547 title('Odds of Winning Montecarlo Alternatives')  
548 f = gcf;  
549 exportgraphics(f,'Figure53.png','Resolution',800)  
550 legend("Position",[0.68938,0.041108,0.29637,0.26344])
```

At the end of this algorithm, a Montecarlo analysis is performed to evaluate the frequency with which each alternative emerges as the winner based on the proposed probabilistic scenarios. Additionally, the algorithm includes a timer, although the computational time used is unimportant since this is a planning problem. The presented algorithm provides all the required results for this analysis and the corresponding figure generated for the study.

3.5 Conclusions

In conclusion, using multicriteria decision methods for solving optimal location problems in electric distribution systems proves crucial. These methods provide a systematic approach to evaluate and compare multiple criteria simultaneously, allowing for a comprehensive analysis of various factors involved in the decision-making process. By considering reliability indicators, cost considerations, constraints on reliability, efficiency and quality of electrical power, and other relevant factors, the multicriteria decision method helps identify the optimal locations for placing reclosers or other system components. This approach enables efficient and adequate decision-making in enhancing the reliability and performance of electric distribution systems.

The proposed method enables a more efficient study of the winning alternative, significantly reducing the computational time as it focuses on exploring only necessary alternatives. However, it is essential to note that the new solution depends on a previously identified dominant solution. The optimization analysis using multicriteria decision is performed across different pseudo-random data generations, providing a more precise understanding of the probability of each switching possibility becoming a winning alternative for the recloser installation. This analysis incorporates the robust probabilistic theory of the Monte Carlo method, which is well-suited for this type of study. The winning probability of each alternative was calculated through 100,000 Monte Carlo scenarios with an absolute error of 0.0032. The alternative of placing two reclosers at P2 and P5 and the existing one at P1 emerged as the winner in 58 per cent of the evaluated alternatives. The proposed method of section coordination was validated through an exhaustive search, demonstrating that it does not compromise the optimal result and consistently identifies the same winning alternative in 64 percent of the random scenarios examined.

It is worth noting that the proposed model is equally applicable to a distribution system where accurate data is available. The optimal switching location and coordination can be precisely determined using the multicriteria method based on the provided data.

In this work, the optimization problem with multicriteria decisions has been formulated. For the compensation problem, the algorithm considers two demand scenarios. It calculates power flows with discretized compensation using an Exhaustive Search algorithm, which determines the location of discretized capacitances among a set of candidate buses. Based on these preliminary results, a second algorithm is developed that assigns weights to each variable, tailored to a minimization criterion. As a result, each compensation scenario obtains a weighted solution, with some solutions discarded based on the dominance criterion. Ultimately, the optimal solution that satisfies the criteria is chosen. This methodology ensures that the compensation solution aligns with correct operational outcomes for reactive power compensation in distribution systems, considering distributed resources.

Furthermore, the research analyzes a case where Total Harmonic Distortion (THD) is not considered an objective criterion. The results demonstrate the conflicts between the analyzed variables in the system under study, which justifies and supports the proposed methodology.

The proposed methodology offers innovative solutions, emphasizing the importance of treating the problem of reactive power compensation as a multicriteria problem and considering a more comprehensive range of quality and efficiency variables than previously addressed by other authors.



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