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Prioritization of Medium-Voltage Wiring Actions With Artificial Intelligence Algorithm

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Abstract: In power distribution networks, keeping quality of service indexes at high levels (SAIDI and SAIFI) can be accomplished through preventive maintenance interventions, which are scheduled by utility's maintenance planning professionals. They are responsible for planning maintenance actions consisting of replacing damaged and obsolete devices and installing new devices, while respecting a certain budget availability. Among all possible actions, spacer cable (SC), phase separators (FS) and tree pruning (TP) are aimed to correct issues on medium-voltage wiring (MVW). Through these actions, impending wiring-related failures are mitigated or even avoided. Currently, utilities' planning professionals may inaccurately determine the annual set of maintenance actions, due to the use of recorded measurements, data from multiple convoluted spreadsheets and personal experience. This paper presents the development of an automated computational tool aimed to prioritize MVW-related maintenance actions, assisting planning professionals in optimizing the use of annual available budget.

Resumo: Em redes elétricas de distribuição, intervenções de manutenção preventiva em redes de distribuição de energia elétrica, gerenciadas pelos profissionais de planejamento, propiciam altos níveis dos índices de qualidade do serviço (DEC e FEC). Eles são responsáveis por planejar obras de manutenção que consistem em substituir equipamentos avariados e obsoletos e instalar novos dispositivos, observando determinada disponibilidade orçamentária. Dentre as possíveis obras de manutenção, cabo spacer, espaçador de fases e poda de árvores se destinam solucionar problemas relativos a cabeamento de redes de média tensão. Com essas obras, problemas iminentes com cabeamento são mitigados ou, até mesmo, evitados. Atualmente, é provável que os profissionais de planejamento da manutenção determinem o conjunto anual de obras de manutenção de forma imprecisa, devido ao uso de medições, diversas planilhas eletrônicas e experiência. Este artigo apresenta o desenvolvimento de uma ferramenta computacional automatizada para priorização de obras relativas a cabeamento de média tensão e auxiliar os profissionais de planejamento de manutenção a otimizar o uso do orçamento anual disponível.

Keywords: Optimization; Genetic algorithms; Maintenance planning; Asset management; Quality of service; Electric power distribution.

Palavras-chaves: Otimização; Algoritmos Genéticos; Planejamento da manutenção; Gestão de ativos; Qualidade do serviço; Distribuição de energia elétrica.

1 INTRODUCTION

Stable and reliable power distribution service is granted by maintenance planning professionals (H. Zhao et al, 2016). Their work consists of identifying and selecting an optimal set of power network interventions, while respecting a preset budget availability.

A group of maintenance actions aimed at medium-voltage wiring (MVW) is comprised of spacer cable (SC), phase separator (PS) and tree pruning (TP). By taking such actions, imminent power interruptions and damages to power equipment and customers are mitigated or even avoided (J. S. Correa-Tamayo et al, 2019). Consequently, significant gains are reflected on quality of service indexes DEC and FEC (ANEEL, 2018), which are Brazilian equivalent indexes for SAIDI and SAIFI, respectively. It is crucial for power distribution utilities to meet ANEEL's annual goals on improving those indexes, preventing the payment of fines and compensations (G. A. B. Conde et al, 2013).

Currently, maintenance professionals receive a list of necessary MVW actions, which are generated by inspection crews. Based on multiple data such as networks' topology, number of customers, power outages records, among other parameters, planning professionals prioritize MVW actions, while attempting to optimize the available annual budget.

Presently, utilities' planning professionals may inaccurately prioritize such actions, due to the use of convoluted spreadsheets, personal experience and few automated tools. Furthermore, this current procedure may prevent optimal allocation of annual available budget.

In related literature, distribution networks maintenance approaches are addressed through SC, PS and TP separately. Reference (A. Cardoso et al, 2009) presents results showing that SC reduce power outages. Research W. H. Bernardelli (2017) considers power outages to suggest actions of replacing conventional cables with SC cables, without explicitly considering available budget restriction. Research (P. Dehghanian et al, 2011) proposes a reliability-centered approach to assist utility's planner with scheduling budget-constrained maintenance actions. In reference (P. Hilber et al, 2005), a customer power outage cost-based methodology to assess cable replacement actions is presented. However, evaluated necessary actions are simply sorted in descending order. Tree pruning should also be considered as alternative maintenance actions, once it is considered a cost-effective approach to improve power supply reliability (S. D. Guikema et al, 2006).

This paper introduces the development of the Wiring Actions Prioritization (WAP), an automated computational module aimed at prioritizing medium-voltage wiring actions employing a genetic algorithm (GA). By analyzing power outages records, network topology, customers' information, among other parameters, the WAP module determines which MVW actions will effectively be conducted. Therefore, the main contribution of this paper consists of deciding not only the MVW actions locations, but also which option (SC, PS or TP) is best suited for each case.

The devised computational tool is applied to case studies involving power distribution networks belonging to the service area served by power utility EDP, that supports this work. By varying some configuration parameters, the corresponding effects on prioritized actions are assessed.

In the following sections, Section 2 introduces the methodology and Section 3 presents case studies. Finally, Section 4 comprises final comments and conclusions.

2 METHODOLOGY

2.1 The problem of actions prioritization

Field inspection crews suggest multiple needs for MVW interventions through installing spacer cable. However, the detected problems may be addressed through cheaper options, such as installing phase separator or tree pruning. Planning professionals are required to determine which actions must be conducted and which option (SC, PS or TP) is most suitable.

By comparing actions options, it is necessary to consider the corresponding costs over a given time interval (TI), such as SC lifespan. Thereby, the remaining options' costs, over TI, are brought to present value.

2.2 Methodology overview

The prioritizing methodology is initiated by WAP receiving a set of input data, consisting of a list of MVW necessary actions registered on utility's ERP (Enterprise Resource Planning) system, power networks' topological data available on utility's GIS (Geographic Information System), power outages during previous years available on OMS (Outage Management System). Next, all necessary MVW actions are assessed at a stage called *Benefits Estimation*, supported by a reliability calculation engine implemented on commercial networks simulator. Subsequently, the GA is executed and an optimal set of MVW actions is determined, considering a given budget availability and other technical restrictions. In the end, the set of prioritized MVW actions is displayed. Such steps are illustrated by Figure 1.

2.3 Input data

2.3.1 GIS topological data

Networks' topological data are available on utility's GIS system and describe line sections connections and associated electrical equipment. These data enable analysis concerning number of customers, load blocks arrangement, electric path identification as well as power flow studies.

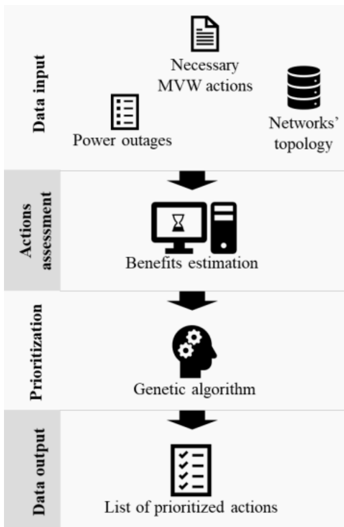

Figure 1 – Methodology steps overview

2.3.2 OMS power outages records

Power outages records concerning the distribution networks are available on utility's OMS system. For each occurrence, registration date, problem cause, position, among other parameters are detailed. On its analysis, WAP module resorts of four parameters: (1) *registration date* helps evaluate the duration of a given malfunction; (2) *power feeder* is considered only if the power outage feeder and the investigated action's feeder are the same; (3) *reference equipment* and (4) *problem cause* helps identify power outage records to be considered.

2.3.3 Options of medium-voltage wiring actions

The main MVW actions characteristics are listed by Table 1, where *Code* represents utility's internal reference, and *Budget* *type* refers to the budget partition to which the action option refers.

Table 1 – Options characteristics

Code	Option description	Budget type
45	Spacer cable	Capex
108	Phase separator	Opex
56	Tree pruning	Opex

2.3.4 Pruning database

Tree pruning actions over a year are recorded in a *Pruning database*, which gathers each action total cost and its position in the network. Based on such data, the WAP module can compute the total cost of a given tree pruning action.

2.3.5 Power outage mitigation

Each option of medium-voltage actions (SC, PS and TP) helps mitigating a specific set of power outage with specific causes, considering specific probabilities, according to Table 2. In this table, along with each mitigated cause, the associated probability is presented, namely Reduction Factor (RF).

Table 2 – Mitigated power outage causes

MVW Option	Mitigated power outage causes and corresponding probabilities
Spacer cable	Equipment deterioration (90%), tree branch (90%), gusts (50%), kite (20%), downed tree (75%), object on network (85%)
Phase separator	Tree branch (100%), gusts (80%), kite (50%)
Tree pruning	Downed tree (100%), tree branch (80%) gusts (80%)

2.4 Actions assessment

By evaluating each MVW action suggestion, WAP module assesses 3 possible options: spacer cable (SC), phase separator (PS) and tree pruning (TP). Each option is evaluated according to the following steps:

1. Estimation of reliability parameters reduction;
2. Simulation of continuity indexes;
3. Calculation of merit index (MI);

WAP module calculations are based on two main reliability parameters: service time (ST), given in hours, and failure rate (FR), given in failures per kilometer. For a given power outage record, ST refers to the total time interval between its registration and the complete reestablishment of the power supply. In its turn, FR refers to the number of power outages, per length unit, associated to a given line section.

When assessing a given MVW action, all mitigatable power outages are selected. Reductions on service time (ΔST) and failure rate (ΔFR) are calculated using Equations (1) and (2), respectively. In these equations, MO is the total number of mitigatable occurrences, TO is the total number of occurrences and RF_i is the reduction factor considered for occurrence *i* and ST_i is the service time associated with such occurrence.

$$\Delta ST = 100\% \cdot \frac{\sum_i^{MO} ST_i \cdot RF_i}{\sum_i^{TO} ST_i} \qquad (1)$$

$$\Delta TF = 100\% \cdot \frac{\sum_i^{MO} RF_i}{TO} \qquad (2)$$

Reliability calculations are conducted considering three types of continuity indexes: interrupted customers (IC), interrupted customers-hours (ICH) and energy not supplied (ENS). Based on topological data of the investigated networks, reliability calculations are conducted through SINAPgrid (Sinapsis Inovação em Energia, 2020) reliability module. As results, initial continuity indexes IC^0, ICH^0 and ENS^0 are provided. Next, reliability parameters ST and FR are altered, considering previously calculated reductions ΔST and ΔFR. Then, reliability calculations are performed to provide IC^1, ICH^1 and ENS^1. The entire process is illustrated by Figure 2.

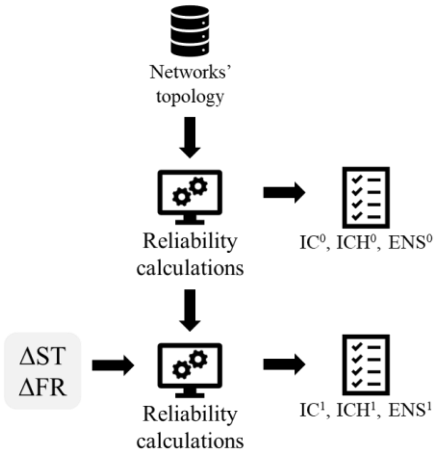

Figure 2 – Steps to estimate continuity indexes gains

In the end, continuity indexes gains (G_{IC}, G_{ICH} and G_{ENS}) are calculated, related to IC, ICH and ENS, using Equations (3), (4) and (5), respectively.

$$G_{IC} = 100\% \cdot \frac{IC^0 - IC^1}{IC^0} \qquad (3)$$

$$G_{ICH} = 100\% \cdot \frac{ICH^0 - ICH^1}{ICH^0} \qquad (4)$$

$$G_{ENS} = 100\% \cdot \frac{ENS^0 - ENS^1}{ENS^0} \qquad (5)$$

Merit index (MI) represents an action's overall evaluation and is calculated with Equation (6), where k_{GIC}, k_{GICH} and k_{GENS} are coefficients related to G_{IC}, G_{ICH} and G_{ENS}, respectively, and C_{TOT} is the total cost. The analyzed action's priority is represented by coefficient k_{PR}, defined with Equation (7), and is a function of the registration time t_{YEARS}.

$$IM = k_{PR} \cdot \frac{k_{GIC} \cdot G_{IC} + k_{GICH} \cdot G_{CICH} + k_{ENS} \cdot G_{ENS}}{C_{TOT}} \qquad (6)$$

$$k_{pr} = 1 \cdot (1 + t_{YEARS}) \qquad (7)$$

2.5 Actions prioritization

2.5.1 Genetic algorithm

Genetic algorithms comprise artificial intelligence techniques aimed to solve generic problems, based on species evolutionary theory. A particular solution to the problem is represented by a GA individual, comprised of a genes chromosome, where each gene codifies a specific feature of the solution. Over GA simulated generations, individuals are subject to two processes: Mutation (genes are randomly altered) and Crossover (randomly chosen individuals exchange genes at similar positions). At the end of a given generation, most adapted individuals are selected to the following generation (Simon, 2013).

2.5.2 Application of GA to prioritize actions

An individual's chromosome consists of three sections, each referring to options SC, PS and TP. As shown in Figure 3, the numbers of genes in each section are N_1, N_2 and N_3, respectively.

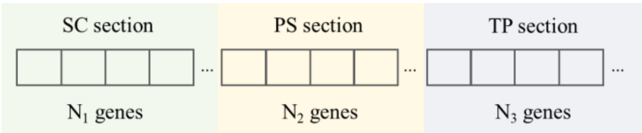

Figure 3 - Individual's chromosome

Action option SC cost is paid with Capex budget. Then, N_1 is calculated with Equation (8), where CPX_{SC} is Capex portion destined to SC actions and AVC_{SC} is the average cost of SC actions. Action options PS and TP are paid with Opex budget. Then, N_2 and N_3 are calculated with Equations (9) and (10), where OPX_{MVW} is Opex portion destined to MVW actions and AVC_{PS} and AVC_{TP} are the average costs of PS and TP options, respectively. Proportion between PS and TP actions is represented by coefficient a, as in Equation (11).

$$N_1 = \frac{CPX_{SC}}{AVC_{SC}} \qquad (8)$$

$$N_2 = \frac{a \cdot OPX_{MVW}}{AVC_{PS}} \qquad (10)$$

$$N_3 = \frac{(1-a) \cdot OPX_{MVW}}{AVC_{TP}} \qquad (11)$$

An individual's Fitness Function (FF) is calculated with Equation (12). For individual j, MI_i is the Merit Index of action i, N is the individual's total number of actions and k_{pen} is a penalty coefficient, defined by Equation (13), where C_{TOT} is the total cost of individual j, and B_{TOT} is the total budget.

$$FF_j = k_{pen} \cdot \sum_{i=1}^{N} MI_i \qquad (12)$$

$$k_{pen} = \begin{cases} \sim 0, & C_{TOT} > B_{TOT} \\ \frac{C_{TOT}}{B_{TOT}}, & C_{TOT} \leq B_{TOT} \end{cases} \qquad (13)$$

The Stopping Criterium consists of a preset total number of iterations. Once this condition is met, GA is interrupted, and the best individual is considered the provided solution. Its genes correspond, one by one, to the actions that must be conducted.

3 APPLICATION TO CASE STUDIES

3.1 Definitions

Consider medium-voltage networks comprised of eight power feeders belonging to substation Cezar de Souza area. These networks serve 40,532 customers, 1,253 MV/LV transformers and 358 km of line sections. Over the last 5 years, 12,302 power outages were recorded, 5,423 of which were associated with the following causes: gusts, kite, device deterioration, tree branch and downed tree. Power outages with these causes may be mitigated through options SC, PS and TP. The following case studies refer to 113 MVW actions listed in Table 3. In this table, *ID* refers to an action's identification, *Local* means the site where it is meant to take place and *Ext* refers to its extension, in kilometers. In all cases, the following budgets are considered: R$ 1,600,000.00 of Capex destined to SC and R$ 100,000.00 Opex destined to PS and TP.

3.2 Case study 1 - distance between phase separators

In this case study, MVW actions are prioritized considering 4 distances between phase separators: D_{PS} = 2m, 3m, 4m and 5m. For each value of D_{PS},

Table 4 lists prioritized actions with highest merit indexes (MI) and those with lowest MI. OPT refers to action option prioritized: TP, PS or SC.

Analyzing those results, one can notice that MI of TP options are the highest, because TP options bring about low-cost benefits, if compared with PS and SC. For PS options, one can notice that, overall, their MI increase with the increase of distance between phase separators. For instance, action with ID = 1 has PS option presents MI varying from 5.35 (for D_{PS} = 2m) to 13.37 (for D_{PS} = 5m), an increase of 150%. It is also noticeable that the increase of distance between phase separators yields to more prioritized actions with option PS. For D_{PS} = 2m, only prioritized action (ID = 87) considers option PS, whereas for D_{PS} = 5m, 3 actions are prioritized considering option PS (ID = 9, 74 and 99). This occurs because PS options become more competitive compared to TP options, because the increase of distance between phase separators reduces option's total cost.

Finally, it is noticeable that prioritized option changed with the increase of the distance between phase separators. For D_{PS} = 2m, action with ID = 9 was prioritized considering option SC and, for D_{PS} = 5m, this same action was prioritized considering PS option. This occurred because with the increase of distance between phase separators, PS option presented increase of merit index. Similar analysis is made for action with ID = 74. For D_{PS} = 2m, SC was the prioritized option and, for D_{PS} = 4m and 5m, PS was the prioritized option, which is due to the increase of PS merit index compared to those of SC and TP.

3.3 Case study 2 – influence of time horizon

For proper comparison among SC, PS and TP options, a time horizon (TH) equivalent to SC's lifespan is established. During this time interval, SC option is executed only once, whereas TP option must be repeated annually or semiannually, due to vegetation natural growth. In this case study, four values of TH are considered: TH = 15, 20, 25 and 30 years. For each. TH value,

Table 4 illustrates resulting merit indexes for SC, PS and TP options. In this table, MI refers to options' alternatives: spacer cable (SC), phase separator (PS) and tree pruning (TP). Column OPT lists prioritized option for each suggested action.

Analyzing table results, with the increase of considered time horizon, an increase of SC option merit index is observed. For instance, action with ID = 1 presents MI = 5.86 for TH = 15 years and MI = 8.69 for TH = 30 years, representing an increase of 48%.

Table 3 – Maintenance actions to be evaluated

ID	Local	Ext	ID	Local	Ext	ID	Local	Ext	ID	Local	Ext
1	130BF00001692	0.095	29	130CF00070315	0.07	57	130CF00540952	0.54	85	130BF00001571	0.18
2	130BF00001692	0.18	30	130CF00070339	0.03	58	130RL00071681	0.12	86	130BF00001796	0.55
3	130BF00001692	0.15	31	130CF00070354	0.27	59	130RL00071681	0.09	87	130BF00001841	0.06
4	130BF00001569	0.45	32	130CF00070354	0.33	60	130RL00071681	0.24	88	130BF00001913	0.21
5	130BF00000841	0.8	33	130BS00549910	0.54	61	130RL00509407	0.15	89	130BF00002318	0.69
6	130RL00509408	0.66	34	130BS00549910	0.24	62	130RL00509407	0.3	90	150BF00001109	0.51
7	130RL00509408	0.81	35	130BS00549910	0.6	63	150CF00070355	0.87	91	130BF00000213	0.975
8	130BF00070934	1.6	36	130CF00000882	0.04	64	150CF00070355	0.54	92	130BF00000247	0.85
9	130BF00521840	0.12	37	130RL00509407	0.15	65	130CF00000880	0.18	93	130BF00000250	0.67
10	130BF00070934	0.21	38	130RL00549095	0.06	66	130BF00002409	0.15	94	130BF00000251	0.37
11	130BF00070934	0.15	39	130BF00070949	0.24	67	130BF00537146	0.21	95	130BF00000252	1.1
12	130BF00000216	0.85	40	130BF00070949	0.27	68	130BF00000205	0.2	96	130BF00000252	0.99
13	130BF00000399	0.5	41	130BF00070949	0.24	69	130BF00000213	1.03	97	130BF00000516	0.11
14	130BF00001113	0.42	42	130BF00070949	0.27	70	130BF00000234	0.42	98	130BF00001330	1.1
15	130CF00070917	0.09	43	130CF00000886	0.21	71	130BF00000235	0.75	99	130BF00001713	0.09
16	130CF00070917	0.12	44	130CF00070210	0.15	72	130BF00000236	0.5	100	130BF00001813	0.09
17	130CF00070917	0.09	45	130CF00070210	0.03	73	130BF00000245	1.25	101	130BF00001813	0.19
18	150CF00070918	0.34	46	130CF00070216	0.3	74	130BF00000272	0.12	102	130BF00001813	0.1
19	150CF00070918	0.18	47	130CF00070247	0.18	75	130BF00000435	0.18	103	130BF00001813	0.33
20	290CF00070923	0.121	48	130CF00070247	0.12	76	130BF00001128	0.42	104	130CF00070338	0.95
21	290CF00070923	0.161	49	130CF00070846	0.18	77	130BF00001130	0.72	105	130CF00070846	1.59
22	290CF00070923	0.592	50	130CF00527739	0.36	78	130BF00001131	0.8	106	130BF00000247	1
23	290CF00070923	0.153	51	130CF00527863	0.36	79	130BF00001132	0.12	107	130CF00070338	0.99
24	130BF00070949	0.27	52	130RL00071694	0.21	80	130BF00001132	0.48	108	130RL00071681	0.15
25	130CF00070311	0.69	53	130CF00000882	0.3	81	130BF00001288	0.38	109	150CF00070940	0.3
26	130CF00070312	0.33	54	130CF00070944	0.9	82	130BF00001565	0.21	110	130BF00001128	0.5
27	130CF00070315	0.09	55	130CF00070945	1.46	83	130BF00001567	0.18	111	130BF00001130	0.3
28	130CF00070315	0.03	56	130CF00502994	0.33	84	130BF00001570	0.48	112	130BF00001130	0.4
									113	130BF00001130	0.38

Table 4 – Results of actions prioritization as function of time horizon considered

TH = 15 years					TH = 20 years					TH = 25 years					TH = 30 years				
ID	MI			OPT	ID	MI			OPT	ID	MI			OPT	ID	MI			OPT
	TP	PS	SC			TP	PS	SC			TP	PS	SC			TP	PS	SC	
1	100	8.91	5.86	TP	1	100	10.70	7.04	TP	1	100	12.10	7.96	TP	1	100	13.20	8.69	TP
2	21.45	1.01	0.70	TP	2	21.45	1.21	0.84	TP	2	21.45	1.37	0.94	TP	2	21.45	1.49	1.03	TP
3	21.45	1.21	0.82	TP	3	21.45	1.45	0.99	TP	3	21.45	1.64	1.12	TP	3	21.45	1.79	1.22	TP
4	7.35	1.37	1.92	TP	4	7.35	1.65	2.30	TP	4	7.35	1.86	2.60	TP	5	5.51	0.66	1.19	TP
5	5.51	0.45	0.80	TP	5	5.51	0.54	0.96	TP	6	4.44	1.78	2.21	TP	6	4.44	1.94	2.41	TP
6	4.44	1.31	1.63	TP	6	4.44	1.57	1.96	TP	7	4.44	1.45	1.99	TP	7	4.44	1.58	2.17	TP
7	4.44	1.07	1.47	TP	7	4.44	1.28	1.76	TP	...					...				
8	2.23	0.59	0.83	TP	8	2.23	0.71	1.00	TP	37	0	0.22	0.81	SC	37	0	0.24	0.88	SC
...					...					49	0	0.28	0.94	SC	49	0	0.30	1.03	SC
37	0	0.17	0.59	SC	49	0	0.24	0.83	SC	74	0	16.57	11.46	PS	74	0	18.07	12.50	PS
49	0	0.20	0.69	SC	74	0	14.65	10.13	PS	75	0	0.20	1.07	SC	75	0	0.22	1.17	SC
74	0	12.20	8.44	PS	75	0	0.18	0.94	SC	96	0	0.60	0.56	PS	78	0	0.01	0.02	SC
75	0	0.15	0.79	SC	94	0	3.11	3.74	SC	99	0	4.75	3.34	PS	94	0	3.84	4.61	SC
94	0	2.59	3.11	SC	99	0	4.20	2.96	PS	104	0	0.11	0.88	SC	98	0	1.19	1.51	SC
99	0	3.50	2.46	PS	105	0	0.13	1.50	SC	105	0	0.15	1.70	SC	99	0	5.19	3.65	PS
															105	0	0.16	1.85	SC

Besides, one can notice reduction of prioritized actions with TP option. This occurred because, with the increase of considered time horizon, it is necessary to conduct TP actions more frequently, causing it to be less advantageous compared to SC option.

3.4 Case study 3 – influence of registration year

In this case study, two situations are considered. In Situation 1, all actions' registration year are the same: 2019. In Situation 2, actions with ID = 1 to 5 are registered in 2019 and all remaining actions are registered in 2016. In both situations, the most relevant actions prioritized (highest merit indexes) are listed in Table 5.

Table 5 – Prioritization results for Situations 1 and 2

SITUATION 1						SITUATION 2					
ID	REG	MI			OPT	ID	REG	MI			OPT
		TP	PS	SC				TP	PS	SC	
3	2019	100	6.78	4.60	TP	3	2019	100	6.78	4.60	TP
2	2019	100	5.65	3.89	TP	2	2019	100	5.65	3.89	TP
1	2019	100	10.70	7.04	TP	1	2019	100	10.70	7.04	TP
6	2019	20.67	7.34	9.12	TP	6	2016	54.15	19.22	23.88	TP
7	2019	20.67	5.98	8.21	TP	7	2016	54.15	15.66	21.50	TP
4	2019	7.35	1.65	2.30	TP	4	2019	7.35	1.65	2.30	TP
5	2019	5.51	0.54	0.96	TP	8	2016	5.83	1.86	2.63	TP
12	2019	0.47	0.37	0.56	SC	5	2019	5.51	0.54	0.96	TP
13	2019	0.44	0.50	0.74	SC	12	2016	1.22	0.96	1.47	SC
14	2019	0.37	0.32	0.22	TP	13	2016	1.14	1.32	1.94	SC
32	2019	0	0.32	2.19	SC	32	2016	0	0.84	5.73	SC
...						...					

Analyzing listed data, one can notice that actions registered in 2016 present higher merit indexes compared to those registered in 2019. Considering action 6 as example Situation 1 (action registered in 2019) presents merit indexes 20.67, 7.34 and 9.12 for options TP, PS and SC, respectively. On the other hand, in Situation 2, action 6 (registered in 2016) presents merit indexes 54.15, 19.22 and 23.88, respectively, representing increase of 162%.

Those results happen because actions registered more previously present merit indexes multiplied by factors which are function of registry year. Therefore, such actions become more competitive compared to the most recent ones.

4 CONCLUSIONS

The context of power utilities maintenance professionals is comprised of many corporate systems data, field measurements and several procedure rules. In this context, the development of a Wiring Actions Prioritization (WAP) tool, presented by this paper, provides important contribution in terms of data processing and analyses automation aiming to optimize total available budget.

Regarding the devised WAP tool, resorting of genetic algorithm enabled complex optimizations, comprising the determination of the sites where actions must take place, as well as which option is the most suitable: spacer cable, phase separator or tree pruning.

Through case studies presented, it was possible to verify the results behavior in face of variations in input data and configuration parameters. For example, one can verify that considering longer time horizon implies more frequent tree pruning actions, causing this option to be more expensive and, therefore, less efficient. Moreover, considering registration year directly affects its merit index, causing actions registered more previously to be more competitive compared to the remaining actions.

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